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PROPERTIES OF THE UPPER ATMOSPHERE

Rocketsonde and Satellite Measurements of Pressure, Temperature, Density, and Composition through Early 1960

790 225

Project ARIES
Contract Nonr 3071(00)
1 August 1960

Science Communication, Inc.
1079 Wisconsin Avenue, N.W.
WASHINGTON, D. C.

SC

Science Communication
Washington, D. C.

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Rocketsonde and Satellite Measurements of Pressure, Temperature, Density, and Composition Through Early 1960

INFORMATION SOURCES AND TREATMENT

The data given in this compilation were obtained from reports, publications, and direct communication with scientists who have made upper atmosphere structure measurements with sounding rockets and satellites. Data are reported for the 30 to 300 kilometer altitude range. It is estimated that over 90 per cent of the data available through the Spring of 1960 are presented in this tabulation. Only data considered "publishable" by the authors (i.e., technically suitable for general use) are included.

An effort has been made to provide an accurate compilation and to present information about the experimental circumstances associated with the measurement. Should the reader encounter technical errors, corrections will be gratefully received and an errata sheet issued.

The compilers have not "evaluated" data obtained.

Those who wish to make critical discrimination among the tabular entries are urged to review the appropriate abstract-references and instrumentation discussions cited in this report.

The data are presented in two tables. The first presents temperature, pressure, and density. The second presents composition measurements. Both are arranged by altitude.

Abstract-bibliographies of key source documents are presented in Appendix B. An abstract-bibliography of general review publication on the upper atmosphere is provided in Appendix C.

The functional principles, an illustrative description, and key references for the instruments employed in the measurements reported are described in Appendix A. The instrument discussions place particular emphasis on sources of error.

NOTATIONS IN TABLES

Errors

The "e" columns immediately to the right of the Pressure, Temperature, and Density columns are the probable errors of the measurement, as obtained from the author. The notation (nf) (in this section and elsewhere) indicates that the information was "not found".

Flight Number

Most of the entries in the "Number" column are IGY rocket flight code numbers. The system is described in the conversion aids at the end of this introductory section. Various designations were used for rocket flights made before the IGY program, and are included whenever they were available.

Time

Flight times are given in local time (to communicate diurnal significance), following the practice in research reports and papers. A time-zone conversion table is given in the conversion aids section.

Altitude

Altitude is given in kilometers. Altitude measurements at all launch sites were made by the DOVAP system, which has an estimated accuracy of ±1 meter. An altitude conversion table (kilometers - miles - feet) is given in the conversion aids section.

Temperature

Temperature is presented in degrees Kelvin. A temperature conversion table ($^{\circ}K$ - $^{\circ}C$ - $^{\circ}F$) is given in the conversions aids sections that follows.

Science Communication
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Project ARIES - Contract Nonr 3071(00)
Final Report
1 August 1960

IGY Rocket Numbering Code

Flight Number: Example: A M 3 07 F

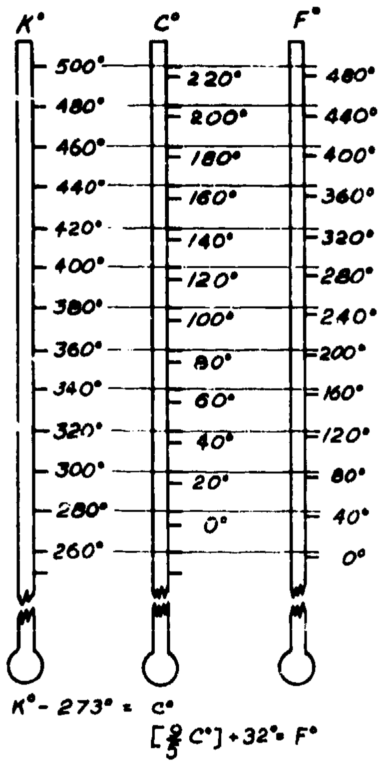
- Place 1. Directing Agency — A
- Place 2. Instrumenting Agency — M
- Place 3. Type of Vehicle — 3
- Place 4. Directing Agency's Serial Number — 07
- Place 5. Purchaser of Vehicle, if not Directing Agency — F

Symbols used in Places 1, 2, and 5

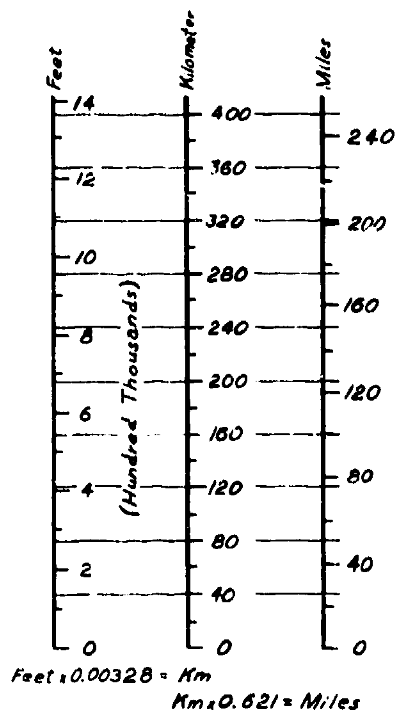
A. Air Force Cambridge Research Center
B. Ballistic Research Laboratories
F. National Science Foundation
M. University of Michigan
N. Naval Research Laboratory
S. Army Signal Corps

Symbols used in Place 3

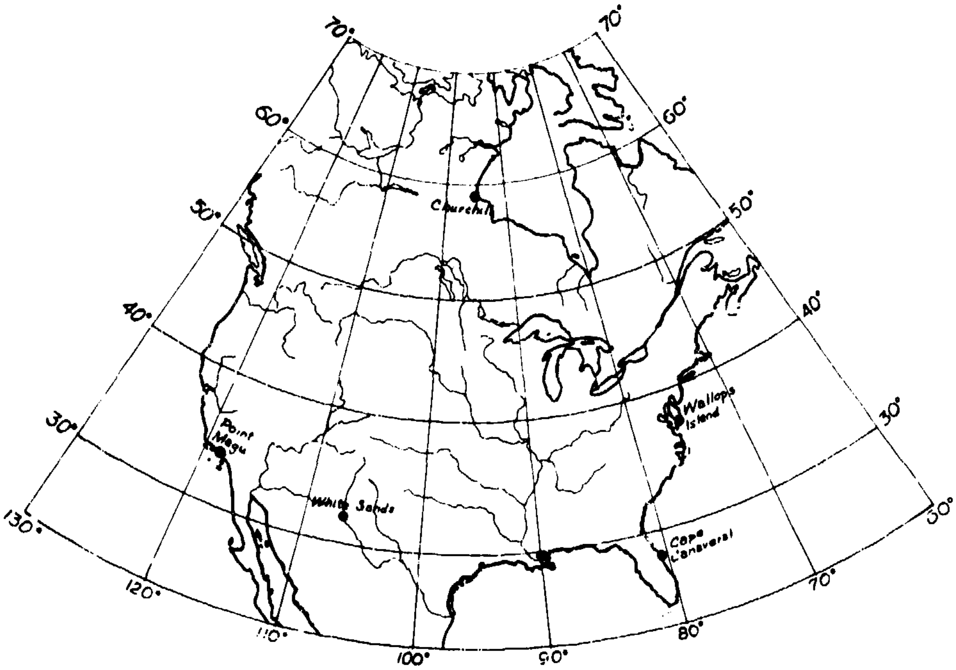
1. & 2. Aerobee
3. & 4. Aerobee-Hi
5. Balloon-rocket (Rockoon)
6. Nike-Cajun
7. Nike-Deacon (DAN)
8. Nike-Asp
9. Loki II-Dart
10. Spaerobee
12. Aerobee 75



Temperature Conversion Table



Height Conversion Table



PLACE	**ZONE**	**TIME**								
Greenwich	GMT	0000	0300	0600	0900	1200	1500	1800	2100	2400
Wallops Island	EST	1800	2100	2400	0300	0600	0900	1200	1500	1800
Fort Churchill	CST	1700	2000	2300	0200	0500	0800	1100	1400	1700
White Sands	MST	1600	1900	2200	0100	0400	0700	1000	1300	1600
Point Mugu	PST	1500	1800	2100	2400	0300	0600	0900	1200	1500

TIME CONVERSION TABLE

Science Communication
Washington, D. C.

UPPER ATMOSPHERE STRUCT
Measurements Reported Throug

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 30-40 Km.		
30	3.0	(p)	-	-	-	-	Pirani gage*	V-2	28
30	1.2	(nf)	-	-	-	-	Alphatron*	Aerobee	(nf)
30	-	-	-	-	234.6	3.0	Grenade	Aerobee	SC-18
30	1.2	(nf)	-	-	230	5.0	Alphatron*	Aerobee	(nf)
30	-	-	-	-	226	8.0	Alphatron*	Aerobee	(nf)
30	-	-	1.8	2	-	-	Sphere*	Aerobee	SC-31
30	-	-	1.8	(p)	-	-	Ionization gage*	Aerobee	AM2.21
30	-	-	1.8	2	213	4.2	Sphere*	Nike-Cajun	AM6.10
30	-	-	1.4	2	213	4.2	Sphere*	Nike-Cajun	AM6.12
30	4.3	(nf)	10.3	(nf)	220	2.0	Grenade	Aerobee	SM1.01
30	8.0	(nf)	17	(nf)	237	2.0	Grenade	Aerobee	SM1.03
30		(nf)	21	(nf)	236	2.0	Grenade	Aerobee	SM1.04
30	6.8	(nf)	14	(nf)	236	2.0	Grenade	Aerobee	SM1.05
30	7.0	(nf)	17	(nf)	201	2.0	Grenade	Aerobee	SM1.07
30	-	-	-	-	208	2.0	Grenade	Aerobee	SM1.08
30	-	-	1.8	2	200	4.0	Sphere*	Nike-Cajun	AM6.02
30	-	-	1.4	2	213	4.2	Sphere*	Aerobee	SM2.10
30	4.6	(nf)	11	(nf)	204	2.0	Grenade	Aerobee	SM2.10
30	1.9	(nf)	18	(nf)	208	2.0	Grenade	Aerobee	SM1.09
30	-	-	1.8	2	210	4.2	Sphere*	Nike-Cajun	AM6.03
30	-	-	1.8	2	223	4.5	Sphere*	Nike-Cajun	AM6.05
30	-	-	1.8	2	213	4.2	Sphere*	Nike-Cajun	AM6.09
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—

* These entries are taken from a published

1

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TUDE RANGE 30-40 Km.							
V-2	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	(nf)- not found (p) - Preliminary, see reference
Aerobee	(nf)	WSPG	20 Jun '50	08.38	MST	Sicinski 54	
Aerobee	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56	
Aerobee	(nf)	WSPG	13 Sep '51	04.37	MST	Sicinski 54	
Aerobee	(nf)	WSPG	26 Sep '51	(nf)	-	Spencer 54	
Aerobee	SC-31	WSPG	29 Sep '53	13.50	MST	Jones 58	
Aerobee	AM2.21	Churchill	23 Oct '56	02.40	CST	Spencer 58-1	
Nike-Cajun	AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
Nike-Cajun	AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
Aerobee	SM1.01	Churchill	12 Nov '56	05.48	CST	Stroud 60 & Bandeen	
Aerobee	SM1.03	Churchill	23 Jul '57	23.30	CST	Stroud 60 & Bandeen	
Aerobee	SM1.04	Churchill	12 Aug '57	10.00	CST	Stroud 60 & Bandeen	
Aerobee	SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	
Aerobee	SM1.07	Churchill	11 Dec '57	22.00	CST	Stroud 60 & Bandeen	
Aerobee	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60	
Nike-Cajun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
Aerobee	SM .10	Churchill	27 Jan '58	12.48	CST	Jones 58	
Aerobee	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	
Aerobee	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
Nike-Cajun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
Nike-Cajun	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
Nike-Cajun	AM6.09	N.Atlantic	2 Nov '59	12.30	GMT	Jones 59	48°57'N 48°22'W

re taken from a published curve. Interpolation for tabular presentation may have introduced an error of ±5%.

2

UPPER ATMOSPHERE STRUCTU
Measurements Reported Through

Altitude Km.	Pressure mm.Hg.	Pressure e.%	Density g/m³	Density e.%	Temperature °K	Temperature e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 30-40 Km.		(C
31	11	(nf)	34	(nf)	239	2.0	Grenade	Aerobee	SM1.02
32.1	-	-	1.8	.22	239	5.0	Sphere*	DAN-2	AM7.02
33.3	-	-	-	-	231.5	4.5	Grenade	Aerobee	SC-16
33.7	-	-	-	-	229	2.1	Grenade	Aerobee	SC-20
35	-	-	-	-	260	2.0	Grenade	Aerobee	SC-8
35	-	-	-	-	235	2.0	Grenade	Aerobee	SC-14
35	-	-	-	-	242	2.0	Grenade	Aerobee	SM2.06
35.4	-	-	-	-	260.7	1.4	Grenade	Aerobee	SC-8
35.9	-	-	-	-	234.9	1.4	Grenade	Aerobee	SC-14
38.7	-	-	-	-	253.0	1.4	Grenade	Aerobee	SC-18
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—

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* These entries are taken from a published curv

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
DE RANGE 30-40 Km.		(Concluded)					
Aerobee	SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60	
DAN-2	Ak7.02	Wallops	24 Jun '55	13.04	EST	Jones 56	
Aerobee	SC-16	WSPG	12 Dec '50	02.10	MST	Stroud 56	
Aerobee	SC-20	WSPG	1 Nov '51	02.46	MST	Stroud 56	
Aerobee	SC-8	WSPG	14 Jul '50	01.37	MST	Weisner 54	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Weisner 54	
Aerobee	SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
Aerobee	SC-8	WSPG	14 Jul '50	01.37	MST	Stroud 56	
Aerobee	SC-14	WSPG	11 Dec '50	20.06	MST	Stroud 56	
Aerobee	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56	

Altitude Range, Km

2

...ken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

UPPER ATMOSPHERE STRUCT
Measurements Reported Through

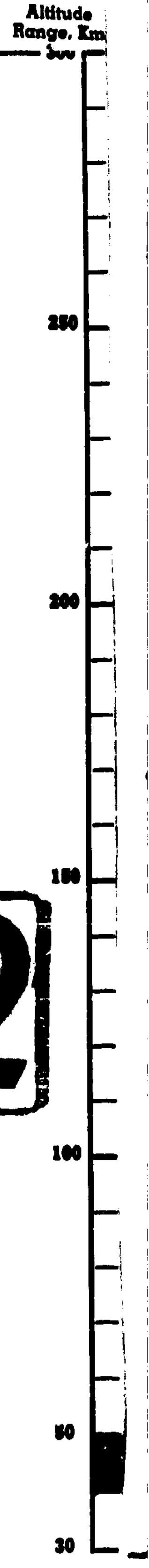
Altitude Km.	Pressure mm.Hg.	Pressure e.%	Density g/m³	Density e.%	Temperature °K	Temperature e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 40-50 Km.		
40	2.0	10	-	-	-	-	Phillips gage*	V-2	21
40	3.0	(nf)	-	-	-	-	Pirani gage*	V-2	28
40	2.0	10	-	-	-	-	Phillips gage*	V-2	45
40	3.0	(nf)	-	-	265	5.0	Alphatron*	Aerobee	(nf)
40	3.0	(nf)	-	-	271	5.0	Alphatron*	Aerobee	(nf)
40	-	-	-	-	277	8.0	Alphatron*	Aerobee	(nf)
40	-	-	4.5	(nf)	-	-	Sphere*	Aerobee	SC-29
40	-	-	4.5	(nf)	-	-	Sphere*	Aerobee	SC-30
40	-	-	4.5	2	-	-	Sphere*	Aerobee	SC-31
40	-	-	3.8	.28	272	16	Sphere*	DAN-2	AM7.02
40	-	-	3.0	(nf)	-	-	Ionization gage*	Aerobee	AM2.21
40	-	-	3.2	2	240	4.8	Sphere*	Nike-Cajun	AM6.10
40	-	-	3.2	2	233	4.6	Sphere*	Nike-Cajun	AM6.12
40	8.0×10^{-1}		1.71	(nf)	240	3.0	Grenade	Aerobee	SM1.01
40	1.7	(nf)	3.3	(nf)	265	3.0	Grenade	Aerobee	SM1.02
40	2.1	(nf)	4.1	(nf)	256	3.0	Grenade	Aerobee	SM1.03
40	2.0	(nf)	3.8	(nf)	260	3.0	Grenade	Aerobee	SM1.04
40	2.5	(nf)	5.1	(nf)	258	3.0	Grenade	Aerobee	SM1.05
40	-	-	-	-	252	3.0	Grenade	Aerobee	SM2.06
40	-	-	-	-	245	3.0	Grenade	Aerobee	SM1.07
40	1.2	(nf)	2.2	(nf)	227	3.0	Grenade	Aerobee	SM1.08
40	-	-	3.7	2	223	4.5	Sphere*	Nike-Cajun	AM6.02
40	-	-	2.3	2	250	5.0	Sphere*	Aerobee	SM2.10
40	1.0	(nf)	2.1	(nf)	233	3.0	Grenade	Aerobee	SM2.10
40	1.5	(nf)	3.1	(nf)	225	3.0	Grenade	Aerobee	SM1.09
40	-	-	2.0	2	282	5.6	Sphere*	Nike-Cajun	AM6.03

* These entries are taken from published cur

ITUDE RANGE 40-50 Km.

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
V-2	21	WSPG	7 Mar '47	11.23	MST	LaGow 54	
V-2	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	(nf)- not found
V-2	45	WSPG	28 Jan '49	10.20	MST	LaGow 54	
Aerobee	(nf)	WSPG	20 Jun '50	08.38	MST	Sicinski 54	
Aerobee	(nf)	WSPG	13 Sep '51	04.37	MST	Sicinski 54	
Aerobee	(nf)	WSPG	26 Sep '51	(nf)	-	Spencer 54	
Aerobee	SC-29	WSPG	11 Dec '52	(nf)	-	Jones 58	
Aerobee	SC-30	WSPG	23 Apr '53	(nf)	-	Jones 58	
Aerobee	SC-31	WSPG	29 Sep '53	(nf)	-	Jones 58	
DAN-2	AM7.02	Wallops	24 Jun '55	13.04	EST	Jones 56	
Aerobee	AM2.21	Churchill	23 Oct '56	02.40	CST	Spencer 58-1	
Nike-Cajun	AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
Nike-Cajun	AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
Aerobee	SM1.01	Churchill	12 Nov '56	05.48	CST	Stroud 60 & Bandeen	
Aerobee	SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60 & Bandeen	
Aerobee	SM1.03	Churchill	23 Jul '57	23.30	CST	Stroud 60 & Bandeen	
Aerobee	SM1.04	Churchill	12 Aug '57	10.00	CST	Stroud 60 & Bandeen	
Aerobee	SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	
Aerobee	SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
Aerobee	SM1.07	Churchill	11 Dec '57	22.00	CST	Stroud 60	
Aerobee	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60 & Bandeen	
Nike-Cajun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
Aerobee	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	
Aerobee	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	
Aerobee	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
Nike-Cajun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	

2



re taken from published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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Washington, D. C.

UPPER ATMOSPHERE STRUC
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numb
							ALTITUDE RANGE 40-50 Km.		
40	-	-	4.0	2	245	4.9	Sphere*	Nike-Cajun	AM6.0
40	-	-	5.0	2	240	4.8	Sphere*	Nike-Cajun	AM6.0
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
40.5	-	-	-	-	253.4	2.3	Grenade	Aerobee	SC-20
41	2.1	(nf)	-	-	-	-	Phillips gage*	Aerobee	(nf)
41.6	-	-	-	-	251.4	1.4	Grenade	Aerobee	SC-8
41.8	-	-	-	-	261.5	1.6	Grenade	Aerobee	SC-14
42	1.7	(nf)	-	-	-	-	Phillips gage*	V-2	34
42	2.0	(nf)	-	-	-	-	Pressure gage*	V-2	43
42	-	-	-	-	262	5.0	Grenade	Aerobee	SC-14
42.1	-	-	-	-	266.5	3.2	Grenade	Aerobee	(nf)
43.5	-	-	-	-	266.5	1.1	Grenade	Aerobee	SC-16
45	1.44	(p)	1.8	(p)	-	-	Ionization gage*	Aerobee	31
45.11	-	-	-	-	311	(p)	Ionization gage*	Aerobee	31
46.3	-	-	-	-	265	2.7	Grenade	Aerobee	SC-20
46.9	-	-	-	-	264.2	2.3	Grenade	Aerobee	SC-18
47.1	-	-	-	-	257.3	0.4	Grenade	Aerobee	(nf)
47.3	-	-	-	-	267.5	1.5	Grenade	Aerobee	SC-8
47.3	-	-	-	-	255.6	3.1	Grenade	Aerobee	(nf)
48	9.0×10^{-1}	(nf)	-	-	-	-	Phillips gage*	(nf)	(nf)
48.1	-	-	-	-	266	1.4	Grenade	Aerobee	SC-14
48.2	-	-	-	-	270	3.6	Grenade	Aerobee	(nf)
48.3	-	-	-	-	262.6	1.4	Grenade	Aerobee	(nf)

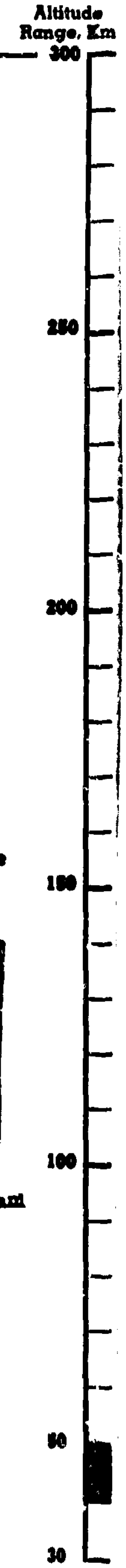
1

* These entries are taken from a publishe

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TITUDE RANGE 40-50 Km.		(cont.)					
Nike-Cajun	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
Nike-Cajun	AM6.09	N.Atlantic	2 Nov '59	12.40	GMT	Jones 59	48°57'N 48°22'W
——	——	——	——	——	—	——	
——	——	——	——	——	—	——	
——	——	——	——	——	—	——	
Aerobee	SC-20	WSPG	1 Nov '51	02.46	MST	Stroud 56	
Aerobee	(nf)	WSPG	3 May '49	09.14	MST	Havens 52	(nf) - not found
Aerobee	SC-8	WSPG	14 Jul '50	01.37	MST	Stroud 56	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52 & LaGow 54	
V-2	43	WSPG	5 Aug '48	18.37	MST	Havens 52 & LaGow 54	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Weisner 54	
Aerobee	(nf)	WSPG	24 Sep '52	20.50	MST	Stroud 56	
Aerobee	SC-16	WSPG	12 Dec '50	02.10	MST	Stroud 56	
Aerobee	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	(p) - Preliminary, see reference
Aerobee	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	
Aerobee	SC-20	WSPG	1 Nov '51	02.46	MST	Stroud 56	
Aerobee	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56	
Aerobee	(nf)	WSPG	24 Apr '53	03.19	MST	Stroud 56	
Aerobee	SC-8	WSPG	14 Jul '50	01.37	MST	Stroud 56	
Aerobee	(nf)	WSPG	22 Oct '52	20.45	MST	Stroud 56	
(nf)	(nf)	Equator	11 May '50	16.00	MST	Havens 52	near Christmas Island
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
Aerobee	(nf)	WSPG	24 Sep '52	20.50	MST	Stroud 56	
Aerobee	(nf)	WSPG	17 Feb '53	24.00	MST	Stroud 56	

2

are taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%



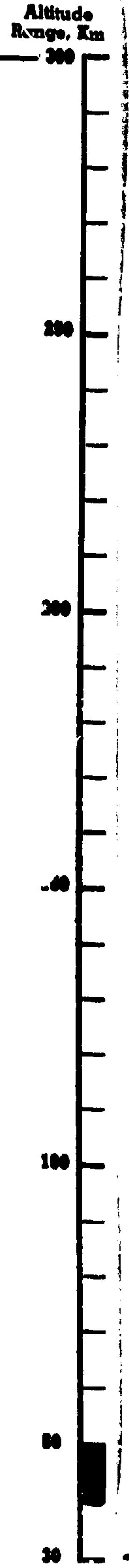
Science Communication
Washington, D. C.

UPPER ATMOSPHERE STRU
Measurements Reported Throu

Altitude	Pressure		Density		Temperature		Instrumentation	Vehicle	Num
Km.	mm.Hg.	e.%	g/m³	e.%	°K	e. °K			
ALTITUDE RANGE 40-50 Km.									
49.9	-	-	-	-	283.7	2.2	Grenade	Aerobee	(nf

1

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TUDE RANGE 40-50 Km.		(concluded)					
Aerobee	(nf)	WSPG	31 Aug '53	22.05	MST	Stroud 56	(nf) - not found



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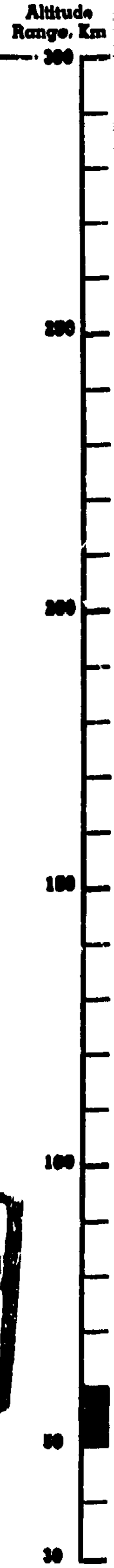
Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
								ALTITUDE RANGE 50-60 Km.	
50	-	-	-	-	315	25	(nf)	V-2	21
50	7.5×10^{-1}	10	-	-	-	-	Phillips gage*	V-2	21
50	9.0×10^{-1}	(nf)	-	-	220	(nf)	Pirani gage*	V-2	28
50	7.5×10^{-1}	(nf)	-	-	-	-	Phillips gage*	V-2	34
50	8.5×10^{-1}	(nf)	3.9×10^{-1}	(nf)	-	-	Pressure gage*	V-2	43
50	6.0×10^{-1}	10	-	-	-	-	Phillips gage*	V-2	45
50	6.4×10^{-1}	(nf)	-	-	-	-	Phillips gage*	Aerobee	(nf)
50	9.0×10^{-1}	(nf)	-	-	270	5.0	Alphatron*	Aerobee	(nf)
50	-	-	-	-	265	3.0	Grenade	Aerobee	SC-10
50	9.5×10^{-1}	(nf)	-	-	268	5.0	Alphatron*	Aerobee	(nf)
50	-	-	-	-	269	9.0	Alphatron*	Aerobee	(nf)
50	-	-	1.0	(nf)	-	-	Sphere*	Aerobee	SC-23
50	0.79	(p)	8.5	(p)	-	-	Alphatron*	Aerobee	31
50	-	-	1.0	(nf)	-	-	Sphere*	Aerobee	SC-29
50	-	-	1.0	(nf)	-	-	Sphere*	Aerobee	SC-30
50	-	-	1.0	2	-	-	Sphere*	Aerobee	SC-31
50	-	-	8.0×10^{-1}	.3	262	5.0	Sphere*	DAN-2	AM7.02
50	-	-	1.0	(nf)	283	(nf)	Sphere*	Nike-Cajun	AM6.01
50	-	-	1.0	(p)	-	-	Ionization gage*	Aerobee	AM2.21
50	-	-	6.0×10^{-1}	2	285	5.7	Sphere*	Nike-Cajun	AM6.10
50	-	-	6.5×10^{-1}	2	260	5.2	Sphere*	Nike-Cajun	AM6.12
50	2.2×10^{-1}	(nf)	4.5×10^{-1}	(nf)	260	4.0	Grenade	Aerobee	SM1.01
50	7.6×10^{-1}	(nf)	1.3	(nf)	270	4.0	Grenade	Aerobee	SM1.02
50	5.0×10^{-1}	(nf)	9.2×10^{-1}	(nf)	275	4.0	Grenade	Aerobee	SM1.03
50	6.8×10^{-1}	(nf)	1.2	(nf)	272	4.0	Grenade	Aerobee	SM1.04
50	6.6×10^{-1}	(nf)	1.2	(nf)	265	4.0	Grenade	Aerobee	SM1.05

* These entries are taken from a publish

HERE STRUCTURE DATA
ported Through Early 1960

Project ARIES — Contract Nonr 3071(00)

icle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
RANGE 50-60 Km.							
2	21	WSPG	7 Mar '47	(nf)		Best 47	(nf) - not found
2	21	WSPG	7 Mar '47	11.23	MST	LaGow 54	
2	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
2	34	WSPG	22 Jan '48	13.13	MST	Havens 52	
2	43	WSPG	5 Aug '48	18.37	MST	Havens 52 & LaGow 54	
2	45	WSPG	28 Jan '49	10.20	MST	LaGow 54	
robee	(nf)	WSPG	3 May '49	09.14	MST	Havens 52	
robee	(nf)	WSPG	20 Jun '50	08.38	MST	Sicinski 54	
robee	SC-10	WSPG	16 Oct '50	21.00	MST	Weisner 54	
robee	(nf)	WSPG	13 Sep '51	04.37	MST	Sicinski 54	
robee	(nf)	WSPG	26 Sep '51	(nf)		Spencer 54	
robee	SC-23	WSPG	14 May '52	(nf)		Jones 58	
robe	21	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	(p) preliminary: see reference
robee	SC-29	WSPG	11 Dec '52	(nf)		Jones 58	
robee	SC-30	WSPG	23 Apr '53	(nf)		Jones 58	
robee	SC-31	WSPG	29 Sep '53	13.50	MST	Jones 58	
-2	AM7.02	Wallops	24 Jun '55	13.04	EST	Jones 56	
e-Cajun	AM6.01	Wallops	6 Jul '56	13.00	EST	Jones 59	
robee	AM2.21	Churchill	23 Oct '56	02.40	CST	Spencer 58-1	
e-Cajun	AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
e-Cajun	AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
robee	SM1.01	Churchill	12 Nov '56	05.48	CST	Stroud 60 & Bandeen	
robee	SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60 & Bandeen	
robee	SM1.03	Churchill	23 Jul '57	23.50	CST	Stroud 60 & Bandeen	
robee	SM1.04	Churchill	12 Aug '57	10.00	CST	Stroud 60 & Bandeen	
robee	SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	



aken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 50-60 Km. ((		
50	-	-	-	-	265	4.0	Grenade	Aerobee	SM 2.0
50	-	-	-	-	255	4.0	Grenade	Aerobee	SM1.07
50	$2.4x10^{-1}$	(nf)	$4.9x10^{-1}$	(nf)	256	4.0	Grenade	Aerobee	SM1.08
50	-	-	$7.5x10^{-1}$	2	253	5.1	Sphere*	Nike-Cajun	AM6.02
50	-	-	1.0	2	255	5.1	Sphere*	Aerobee	SM2.10
50	$2.8x10^{-1}$	(nf)	$5.5x10^{-1}$	(nf)	257	(nf)	Grenade	Aerobee	SM2.10
50	$3.0x10^{-1}$	(nf)	$6.2x10^{-1}$	(nf)	252	4.0	Grenade	Aerobee	SM1.09
50	-	-	$9.5x10^{-1}$	2	280	5.6	Sphere*	Nike-Cajun	AM6.03
50	-	-	1.0	2	263	5.2	Sphere*	Nike-Cajun	AM6.05
50	-	-	$8.5x10^{-1}$	2	255	5.1	Sphere*	Nike-Cajun	AM6.09
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
50.11	-	-	-	-	309	(P)	Alphatron*	Aerobee	31
51	-	-	$6.0x10^{-1}$	(P)	-	-	Ionization gage*	Nike-Cajun	AM6.38
51.5	-	-	-	-	260.4	1.7	Grenade	Aerobee	SC-18
52	$5.7x10^{-1}$	4.1	-	-	-	-	Phillips gage*	Aerobee	(nf)
53.1	-	-	-	-	261	3.9	Grenade	Aerobee	SC-16
53.3	-	-	-	-	263.4	1.7	Grenade	Aerobee	SC-20
53.3	-	-	-	-	278.2	3.7	Grenade	Aerobee	(nf)
54	-	-	-	-	271.1	4.0	Grenade	Aerobee	(nf)
54	-	-	$6.0x10^{-1}$	(P)	-	-	Ionization gage*	Nike-Cajun	AM6.37
54.7	-	-	-	-	251.5	1.7	Grenade	Aerobee	SC-14
54.7	-	-	-	-	262.5	0.4	Grenade	Aerobee	(nf)

* These entries are taken from a published

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RE STRUCTURE DATA
ted Through Early 1960

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
50-60 Km. (cont.)							
	SM 2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
	SM1.07	Churchill	11 Dec '57	22.00	CST	Stroud 60	
	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60 & Bandeen	
jun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	
	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	(nf) - not found
	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
jun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
jun	AM5.05	Churchill	4 Mar '58	15.30	CST	Jones 59	
jun	AM6.09	N.Atlantic	2 Nov '59	12.40	GMT	Jones 59	48°57' N; 48°22' W
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—	—	—	—	—	—	—	
—	—	—	—	—	—	—	
	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	(p) preliminary, see reference
jun	AM6.38	Churchill	24 Mar '58	12.30	CST	Spencer 58-1	
	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56	
	(nf)	WSPG	6 Sep '49	09.57	MST	Havens 52	
	SC-16	WSPG	12 Dec '50	02.10	MST	Stroud 56	
	SC-20	WSPG	1 Nov '51	02.46	MST	Stroud 56	
	(nf)	WSPG	22 Oct '52	20.45	MST	Stroud 56	
	(nf)	WSPG	24 Sep '52	20.50	MST	Stroud 56	
jun	AM6.37	Churchill	24 Feb '58	01.35	CST	Spencer 58-1	
	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
	(nf)	WSPG	[illegible] Apr '53	03.19	MST	Stroud 56	

om a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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Altitude Range, Km: 300, 250, 200, 150, 100, 50, 30

UPPER ATMOSPHERE STRUC
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
								ALTITUDE RANGE 50-60 Km	
55	-	-	-	-	252	4.0	Grenade	Aerobee	SC-14
55.4	-	-	-	-	265.6	4.6	Grenade	Aerobee	SC-18
56	-	-	-	-	249.7	3.8	Grenade	Aerobee	SC-8
58	$3.0x10^{-1}$	(nf)	-	-	-	-	Pressure gage*	V-2	43
58	-	-	-	-	262	3.6	Grenade	Aerobee	SC-10
58.1	-	-	-	-	239.9	1.9	Grenade	Aerobee	(nf)
58.5	-	-	-	-	259	1.6	Grenade	Aerobee	(nf)
58.7	-	-	-	-	258.9	7.2	Grenade	Aerobee	SC-18
59	$2.0x10^{-1}$	(nf)	-	-	-	-	Phillips gage*	Aerobee	(nf)
59	$2.3x10^{-1}$	(nf)	-	-	-	-	Phillips gage*	(nf)	(nf)
59	-	-	-	-	263.9	4.2	Grenade	Aerobee	(nf)
59.3	-	-	-	-	246.2	1.8	Grenade	Aerobee	(nf)
59.6	-	-	-	-	254.3	3.8	Grenade	Aerobee	(nf)

1

* These entries are taken from a publishe

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes	Altitude Range, Km
RANGE 50-60 Km. (concluded)								300
	SC-14	WSPG	11 Dec '50	21.06	MST	Weisner 54		
	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56		
	SC-8	WSPG	14 Jul '50	0.137	MST	Stroud 56		
	43	WSPG	5 Aug '48	18.37	MST	Havens 52 & LaGow 54	(nf) not found	
	SC-10	WSPG	10 Oct '50	21.00	MST	Weisner 54		250
	(nf)	WSPG	31 Aug '53	22.05	MST	Stroud 56		
	(nf)	WSPG	4 Sep '53	22.36	MST	Stroud 56		
	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56		
	(nf)	WSPG	3 May '49	09.14	MST	Havens 52		
	(nf)	Equator	11 May '50	16.00	MST	Havens 52	near Christmas Island	200
	(nf)	WSPG	22 Oct '52	20.45	MST	Stroud 56		
	(nf)	WSPG	17 Feb '53	23.50	MST	Stroud 56		
	(nf)	WSPG	24 Sep '52	20.50	MST	Stroud 56		
—	—	—	—	—	—	—		
—	—	—	—	—	—	—		
—	—	—	—	—	—	—		150

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100

rom a publishe/. curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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30

UPPER ATMOSPHERE STRU

Measurements Reported Thro

Altitude Km.	Pressure mm.Hg.	Pressure e.%	Density g/m³	Density e.%	Temperature °K	Temperature e. °K	Instrumentation	Vehicle	Numbe
								ALTITUDE RANGE 60-70 Km.	
60	-	-	-	-	312	25	(nf)	V-2	21
60	2.2×10^{-1}	(nf)	-	-	250	(nf)	Pirani gage*	V-2	28
60	-	-	3.0×10^{-1}	(nf)	-	-	Pressure gage*	V-2	43
60	2.5×10^{-1}	(nf)	-	-	240	7.0	Alphatron*	Aerobee	(nf)
60	-	-	-	-	250	5.0	Grenade	Aerobee	SC-14
60	2.5×10^{-1}	(nf)	-	-	238	5.0	Alphatron*	Aerobee	(nf)
60	-	-	-	-	240	12	Alphatron*	Aerobee	(nf)
60	-	-	3.5×10^{-1}	(nf)	-	-	Sphere*	Aerobee	SC-23
60	2.5×10^{-1}	(p)	2.8	(p)	277	(p)	Alphatron*	Aerobee	31
60	-	-	4.5×10^{-1}	(nf)	-	-	Sphere*	Aerobee	SC-29
60	-	-	3.0×10^{-1}	(nf)	-	-	Sphere*	Aerobee	SC-30
60	-	-	2.0×10^{-1}	2	-	-	Sphere*	Aerobee	SC-31
60	-	-	3.17×10^{-1}	1	242	4.0	Sphere*	DAN-2	AM7.0
60	-	-	4.0×10^{-1}	(nf)	-	-	Sphere*	Nike-Cajun	AM6.0
60	-	-	2.9×10^{-1}	(p)	-	-	Ionization gage*	Aerobee	AM2.2
60	-	-	2.0×10^{-1}	2	273	5.5	Sphere*	Nike-Cajun	AM6.1
60	-	-	2.0×10^{-1}	2	240	4.8	Sphere*	Nike-Cajun	AM6.1
60	6.6×10^{-2}	(nf)	1.1×10^{-1}	(nf)	260	5.0	Grenade	Aerobee	SM1.0
60	2.1×10^{-1}	(nf)	4.2×10^{-1}	(nf)	260	5.0	Grenade	Aerobee	SM1.0
60	1.8×10^{-1}	(nf)	3.5×10^{-1}	(nf)	260	3.0	Grenade	Aerobee	SM1.0
60	1.7×10^{-1}	(nf)	2.7×10^{-1}	(nf)	258	5.0	Grenade	Aerobee	SM1.0
60	1.8×10^{-1}	(nf)	3.5×10^{-1}	(nf)	255	5.0	Grenade	Aerobee	SM1.0
60	-	-	-	-	255	5.0	Grenade	Aerobee	SM2.06
60	-	-	4.0×10^{-1}	(p)	-	-	Ionization gage*	Aerobee-Hi	AM4.01
60	-	[illegible]	[illegible]	-	242	5.0	Grenade	Aerobee	SM1.07

* These entries are taken from a publishe

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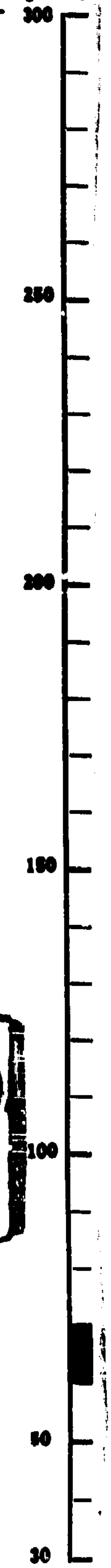
Number	Place Fired	Date	Time	Zone	Reference Data	Notes
) Km.						
21	WSPG	7 Mar '47	11.23	MST	Best 47	(nf) - not found
28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
43	WSPG	5 Aug '48	18.37	MST	Havens 52 & LaGow 54	
(nf)	WSPG	20 Jun '50	08.38	MST	Sicinski 54	
SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
(nf)	WSPG	13 Sep '51	04.37	MST	Sicinski 54	
(nf)	WSPG	26 Sep '51	(nf)	-	Spencer 54	
SC-23	WSPG	14 May '52	(nf)	-	Jones 58	
31	Holloman	22 Oct '52	07.21	MST	Spencer 58-1	(p) Preliminary: see reference
SC-29	WSPG	11 Dec '52	(nf)	-	Jones 58	
SC-30	WSPG	23 Apr '53	(nf)	-	Jones 58	
SC-31	WSPG	29 Sep '53	13.50	MST	Jones 58	
AM7.02	Wallops	24 Jun '55	13.04	EST	Jones 56	
AM6.01	Wallops	6 Jul '56	13.00	EST	Jones 59	
AM2.21	Churchill	23 Oct '56	02.40	CST	Spencer 58-1	
AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
SM1.01	Churchill	12 Nov '56	05.48	CST	Stroud 60 & Bandeen	
SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60 & Bandeen	
SM1.03	Churchill	23 Jul '57	23.30	CST	Stroud 60 & Bandeen	
SM1.04	Churchill	12 Aug '57	10.00	CST	Stroud 60 & Bandeen	
SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	
SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
AM4.01	Churchill	1 Sep '57	16.28	CST	Spencer 58-1	
SM1.07	Churchill	11 Dec '57	22.00	CST	Stroud 60	

Altitude Range, Km



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published curve. Interpo_ation for tabular presentation may have introduced an error of ± 5%.

UPPER ATMOSPHERE STRUC
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/r.	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 60-70 Km.	(c	
60	$5.7x10^{-2}$	(nf)	$1.2x10^{-1}$	(nf)	230	5.0	Grenade	Aerobee	SM1.08
60	-	-	$1.9x10^{-1}$	2	263	5.2	Sphere*	Nike-Cajun	AM6.02
60	-	-	$1.5x10^{-1}$	2	253	5.0	Sphere*	Aerobee	SM2.10
60	$1.1x10^{-1}$	(nf)	$2.2x10^{-1}$	(nf)	255	5.0	Grenade	Aerobee	SM2.10
60	$7.8x10^{-2}$	(nf)	$1.5x10^{-1}$	(nf)	250	5.0	Grenade	Aerobee	SM1.09
60	-	-	$3.0x10^{-1}$	2	258	5.1	Sphere*	Nike-Cajun	AM6.03
60	-	-	$2.8x10^{-1}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.37
60	-	-	$2.5x10^{-1}$	2	238	4.7	Sphere*	Nike-Cajun	AM6.05
60	-	-	$2.0x10^{-1}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.38
60	-	-	$2.9x10^{-1}$	2	-	-	Sphere*	Nike-Cajun	AM6.09
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
60.1	-	-	-	-	249	2.1	Grenade	Aerobee	SC-14
60.5	-	-	-	-	241.8	5.8	Grenade	Aerobee	SC-20
61	$1.8x10^{-1}$	10	-	-	-	-	Phillips gage*	V-2	45
61.2	-	-	-	-	211.6	1.4	Grenade	Aerobee	SC-16
61.8	-	-	-	-	244.6	0.4	Grenade	Aerobee	(nf)
61.9	-	-	-	-	252.2	1.3	Grenade	Aerobee	SC-18
63	$1.4x10^{-1}$	(nf)	-	-	-	-	Phillips gage*	V-2	12
64	-	-	-	-	234	5.0	Grenade	Aerobee	SC-10
64.4	-	-	-	-	233.5	4.0	Grenade	Aerobee	SC-10
64.5	-	-	-	-	244.7	2.3	Grenade	Aerobee	SC-14
65	-	-	-	-	245	5.0	Grenade	Aerobee	SC-14

* These entries are taken from a publishe

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OSPHERE STRUCTURE DATA
s Reported Through Early 1960

Project ARIES — Contract Nonr 3071(00)

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
ITUDE RANGE 60-70 Km. (cont.)							
Aerobee	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60 & Bandeen	
Nike-Cajun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
Aerobee	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	
Aerobee	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	
Aerobee	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
Nike-Cajun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
Nike-Cajun	AM6.37	Churchill	24 Feb '58	01.35	CST	Spencer 58-1	(p) Preliminary: see reference
Nike-Cajun	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
Nike-Cajun	AM6.38	Churchill	24 Mar '58	12.30	CST	Spencer 58-1	(nf)- not found
Nike-Cajun	AM6.09	N.Atlantic	2 Nov '59	12.40	GMT	Jones 59	48°57'N 48°22'W
—	—	—	—	—	—	—	
—	—	—	—	—	—	—	
—	—	—	—	—	—	—	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
Aerobee	SC-20	WSPG	1 Nov '51	02.46	MST	Stroud 56	
V-2	45	WSPG	28 Jan '49	10.20	MST	LaGow 54	
Aerobee	SC-16	WSPG	12 Dec '50	02.10	MST	Stroud 56	
Aerobee	(nf)	WSPG	24 Apr '53	03.19	MST	Stroud 56	
Aerobee	SC-18	WSPG	8 Jun '51	23.11	MST	Stroud 56	
V-2	12	WSPG	10 Oct '46	11.02	MST	Havens 52	
Aerobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
Aerobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	
Aerobee	SC-14	WSPG	11 Dec '50	21.06	MST	Stroud 56	

Altitude Range, Km: 300, 250, 200, 150, 100, 50, 30

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re taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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UPPER ATMOSPHERE STRUCT
Measurements Reported Throug

Altitude Km.	Pressure mm.Hg.	Pressure e.%	Density g/m³	Density e.%	Temperature °K	Temperature e. °K	Instrumentation	Vehicle	Number
								ALTITUDE RANGE 60-70 Km.	(
65	$1.09x10^{-1}$	(nf)	-	-	-	-	Phillips gage*	(nf)	(nf)
65.7	-	-	-	-	236	1.9	Grenade	Aerobee	(nf)
65.8	-	-	-	-	224.5	1.4	Grenade	Aerobee	(nf)
56.6	-	-	-	-	223.4	1.8	Grenade	Aerobee	(nf)
67.3	-	-	-	-	222.1	1.8	Grenade	Aerobee	(nf)
68	$7.0x10^{-2}$	(nf)	-	-	-	-	Phillips gage*	(nf)	(nf)
68.1	-	-	-	-	222.6	0.4	Grenade	Aerobee	(nf)
69.3	-	-	-	-	235.3	1.8	Grenade	Aerobee	(nf)

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* These entries are taken from a publishe

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
LTITUDE RANGE 60-70 Km. (concluded)							
(nf)	(nf)	WSPG	12 Dec '50	24.00	MST	Havens 52	(nf)- not found
Aerobee	(nf)	WSPG	31 Aug '53	22.05	MST	Stroud 56	
Aerobee	(nf)	WSPG	4 Sep '53	22.36	MST	Stroud 56	
Aerobee	(nf)	WSPG	22 Oct '52	20.45	MST	Stroud 56	
Aerobee	(nf)	WSPG	24 Sep '52	20.50	MST	Stroud 56	
(nf)	(nf)	Equator	11 May '50	16.00	MST	Havens 52	near Christmas Island
Aerobee	(nf)	WSPG	24 Apr '53	03.19	MST	Stroud 56	
Aerobee	(nf)	WSPG	17 Feb '53	23.50	MST	Stroud 56	

Altitude Range, Km: 300, 250, 200, 150, 100, 50, 30

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are taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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UPPER ATMOSPHERE STRU

Measurements Reported Thre

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numb
							ALTITUDE RANGE 70-80 Km.		
70	$6.0x10^{-2}$	(nf)	-	-	-	-	Phillips gage*	V-2	12
70	$3.5x10^{-3}$	(p)	-	-	-	-	Ionization gage*	V-2	15
70	-	-	-	-	240	15	(nf)	V-2	21
70	$5.2x10^{-2}$	10	$1.29x10^{-1}$	20	-	-	Phillips gage*	V-2	21
70	$9.0x10^{-2}$	(p)	-	-	260	(p)	Pirani gage*	V-2	28
70	$5.0x10^{-2}$	(nf)	-	-	-	-	Phillips gage*	V-2	34
70	$4.8x10^{-2}$	(nf)	-	-	187	10	Alphatron*	Aerobee	(nf)
70	-	-	-	-	225	6.0	Grenade	Aerobee	SC-10
70	-	-	-	-	189	7.0	Alphatron*	Aerobee	(nf)
70	$5.0x10^{-2}$	(p)	$8.0x10^{-2}$	(p)	216	(p)	Alphatron*	Aerobee	31
70	-	-	$1.0x10^{-1}$	(nf)	-	-	Sphere*	Aerobee	SC-29
70	-	-	$9.8x10^{-2}$	(nf)	-	-	Sphere*	Aerobee	SC-30
70	-	-	$5.5x10^{-2}$	2	-	-	Sphere*	DAN-2	AM7.0
70	-	-	$1.0x10^{-2}$	2	-	-	Sphere*	Nike-Cajun	AM6.0
70	-	-	$5.0x10^{-2}$	2	245	4.9	Sphere*	Nike-Cajun	AM6.1
70	-	-	$6.0x10^{-2}$	2	-	-	Sphere*	Nike-Cajun	AM6.1
70	$4.0x10^{-2}$	(nf)	$9.9x10^{-2}$	(nf)	215	6.0	Grenade	Aerobee	SM1.0
70	$4.6x10^{-2}$	(nf)	$1.04x10^{-1}$	(nf)	220	6.0	Grenade	Aerobee	SM1.0
70	$4.2x10^{-2}$	(nf)	$9.8x10^{-2}$	(nf)	215	6.0	Grenade	Aerobee	SM1.0
70	-	-	-	-	210	5.0	Grenade	Aerobee	SM2.0
70	-	-	$9.5x10^{-2}$	(p)	-	-	Ionization gage*	Aerobee-hi	AM4.0
70	-	-	-	-	280	6.0	Grenade	Aerobee	SM1.0
70	$2.0x10^{-2}$	(nf)	$2.5x10^{-2}$	(nf)	240	6.0	Grenade	Aerobee	SM1.0
70	-	-	$5.5x10^{-2}$	2	243	4.9	Sphere*	Nike-Cajun	AM6.0
70	-	-	$4.0x10^{-2}$	2	233	4.6	Sphere*	Aerobee	SM2.1

* These entries are taken from a publish

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MOSPHERE STRUCTURE DATA
nts Reported Through Early 1960

Project ARIES — Contract Nonr 3071(00)

	Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
LTITUDE RANGE 70-80 Km.								
	V-2	12	WSPG	10 Oct '46	11.02	MST	Havens 52	(nf) not found
s*	V-2	15	WSPG	21 Nov '46	09.55	MST	Spencer 54	(p) preliminary see reference
	V-2	21	WSPG	7 Mar '47	11.23	MST	Best 47	
	V-2	21	WSPG	7 Mar '47	11.23	MST	LaGow 54	
	V-2	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
	V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52	
	Aerobee	(nf)	WSPG	20 Jun '50	08.38	MST	Sicinski 54	
	Aerobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
	Aerobee	(nf)	WSPG	13 Sep '51	04.37	MST	Sicinski 54	
	Aerobee	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	
	Aerobee	SC-29	WSPG	11 Dec '52	(nf)		Jones 58	
	Aerobee	SC-30	WSPG	23 Apr '53	(nf)		Jones 58	
	DAN-2	AM7.02	Wallops	24 Jun '55	13.04	EST	Jones 56	
	Nike-Cajun	AM6.01	Wallops	6 Jul '56	13.00	EST	Jones 59	
	Nike-Cajun	AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
	Nike-Cajun	AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
	Aerobee	SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60 & Bandeen	
	Aerobee	SM1.03	Churchill	23 Jul '57	23.30	CST	Stroud 60 & Bandeen	
	Aerobee	SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	
	Aerobee	SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
s*	Aerobee-hi	AM4.01	Churchill	1 Sep '57	16.28	CST	Spencer 58-1	
	Aerobee	SM1.07	Churchill	11 Dec '57	22.00	CST	Stroud 60	
	Aerobee	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60 & Bandeen	
	Nike-Cajun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
	Aerobee	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	

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UPPER ATMOSPHERE STRUC

Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	Pressure e.%	Density g/m³	Density e.%	Temperature °K	Temperature e. °K	Instrumentation	Vehicle	Numb
								ALTITUDE RANGE 70-80 Km.	
70	$3.0x10^{-2}$	(nf)	$6.[illegible]x10^{-2}$	(nf)	238	6.0	Grenade	Aerobee	SM2.
70	$1.7x10^{-2}$	(nf)	$3.7x10^{-2}$	(nf)	235	6.0	Grenade	Aerobee	SM1.
70	-	-	$8.5x10^{-2}$	2	242	4.8	Sphere*	Nike-Cajun	AM6.
70	-	-	$1.2x10^{-1}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.
70	-	-	$1.0x10^{-1}$	2	247	4.9	Sphere*	Nike-Cajun	AM6.
70	-	-	$5.0x10^{-2}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.
70	-	-	$6.9x10^{-2}$	(nf)	-	-	Sphere*	Nike-Cajun	AM6.
70.1	-	-	-	-	224.4	4.8	Grenade	Aerobee	SC-1
72.5	-	-	-	-	207.1	2.1	Grenade	Aerobee	(nf)
72.7	-	-	-	-	240.6	4.4	Grenade	Aerobee	(nf)
75	-	-	-	-	226.0	6.0	Grenade	Aerobee	SC-1
75.4	-	-	-	-	225.5	6.0	Grenade	Aerobee	SC-1
76.5	-	-	-	-	204.3	2.8	Grenade	Aerobee	(nf)
77	$2.6x10^{-1}$	(nf)	-	-	-	-	Phillips gage*	Aerobee	(nf)
77.8	-	-	-	-	214.5	1.8	Grenade	Aerobee	(nf)
78.7	-	-	-	-	203.4	3.0	Grenade	Aerobee	(nf)

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* These entries are taken from a publishe

PHERE STRUCTURE DATA
eported Through Early 1960

hicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
IE RANGE 70-80 Km.		(concluded)					
erobee	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	
erobee	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
ike-Cajun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
ike-Cajun	AM6.37	Churchill	24 Feb '58	01.35	CST	Spencer 58-1	(p) preliminary see reference
ike-Cajun	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
ike-Cajun	AM6.38	Churchill	24 Mar '58	12.30	CST	Spencer 58-1	
ike-Cajun	AM6.09	N.Atlantic	2 Nov '59	12.40	GMT	Jones 59	(nf) not found 48°57'N 48°22'W
——	——	——	——	——	——	——	
——	——	——	——	——	——	——	
——	——	——	——	——	——	——	
erobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
erobee	(nf)	WSPG	4 Sep '53	22.36	MST	Stroud 56	
erobee	(nf)	WSPG	31 Aug '53	22.05	MST	Stroud 56	
erobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
erobee	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
erobee	(nf)	WSPG	[illegible] Sep '52	20.50	MST	Stroud 56	
erobee	(nf)	WSPG	3 May '49	[illegible].14	MST	Havens 52	
erobee	(nf)	WSPG	17 Feb '53	23.50	MST	Stroud 56	
erobee	(nf)	WSPG	4 Sep '53	22.36	MST	Stroud 56	
——	——	——	——	——	——	——	
——	——	——	——	——	——	——	
——	——	——	——	——	——	——	

Altitude Range, Km

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aken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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UPPER ATMOSPHERE STRUC
Measurements Reported Throug

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 80-90 Km.		
80	$1.0x10^{-3}$	(p)	-	-	-	-	Ionization gage*	V-2	15
80	-	-	-	-	200	20	(nf)	V-2	21
80	-	-	$3.5x10^{-2}$	20	-	-	Phillips gage*	V-2	21
80	$1.3x10^{-2}$	(nf)	-	-	220	(nf)	Pirani gage*	V-2	28
80	-	-	-	-	210	7.0	Grenade	Aerobee	SC-10
80	-	-	$3.0x10^{-2}$	(nf)	-	-	Sphere*	Aerobee	SC-30
80	-	-	$2.0x10^{-2}$	(nf)	-	-	Sphere*	Nike-Cajun	AM6.01
80	-	-	$1.8x10^{-2}$	5	-	-	Sphere*	Nike-Cajun	AM6.10
80	-	-	$2.5x10^{-2}$	5	-	-	Sphere*	Nike-Cajun	AM6.12
80	$8.7x10^{-2}$	(nf)	$2.5x10^{-2}$	(nf)	174	7.0	Grenade	Aerobee	SM1.02
80	$9.0x10^{-3}$	(nf)	$2.6x10^{-2}$	(nf)	170	7.0	Grenade	Aerobee	SM1.03
80	$7.4x10^{-3}$	(nf)	$2.1x10^{-2}$	(nf)	172	7.0	Grenade	Aerobee	SM1.05
80	-	-	-	-	180	7.0	Grenade	Aerobee	SM2.06
80	-	-	-	-	222	7.0	Grenade	Aerobee	SM1.08
80	-	-	$1.5x10^{-2}$	2	-	-	Sphere*	Nike-Cajun	AM6.02
80	-	-	$1.0x10^{-2}$	2	-	-	Sphere*	Aerobee	SM2.10
80	$5.5x10^{-3}$	(nf)	$1.1x10^{-2}$	(nf)	245	7.0	Grenade	Aerobee	SM2.10
80	$6.1x10^{-3}$	(nf)	$7.5x10^{-3}$	(nf)	245	7.0	Grenade	Aerobee	SM1.09
80	-	-	$2.5x10^{-2}$	2	-	-	Sphere*	Nike-Cajun	AM6.03
80	-	-	$3.5x10^{-2}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.37
80	-	-	$2.0x10^{-2}$	(p)	-	-	Sphere*	Nike-Cajun	AM6.05
80	-	-	$1.3x10^{-2}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.38

* These entries are taken from a publishe

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
...E 80-90 Km.							
	15	WSPG	21 Nov '46	09.55	MST	Spencer 54	(p) preliminary; see reference
	21	WSPG	7 Mar '47	11.23	MST	Best 47	(nf) not found
	21	WSPG	7 Mar '47	11.23	MST	LaGow 54	
	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
...e	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
...e	SC-30	WSPG	23 Apr '53	(nf)		Jones 58	
...ajun	AM6.01	Wallops	6 Jul '56	13.00	EST	Jones 59	
...ajun	AM6.10	N.Atlantic	4 Nov '56	12.54	GMT	Jones 59	57°46'N 46°41'W
...ajun	AM6.12	N.Atlantic	10 Nov '56	07.17	GMT	Jones 59	65°36'N 58°03'W
...e	SM1.02	Churchill	21 Jul '57	22.16	CST	Stroud 60 & Bandeen	
...e	SM1.03	Churchill	23 Jul '57	23.30	CST	Stroud 60 & Bandeen	
...e	SM1.05	Churchill	19 Aug '57	20.30	CST	Stroud 60 & Bandeen	
...e	SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
...e	SM1.08	Churchill	14 Dec '57	15.00	CST	Stroud 60	
...ajun	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
...e	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	
...e	SM2.10	Churchill	27 Jan '58	12.49	CST	Stroud 60 & Bandeen	
...e	SM1.09	Churchill	27 Jan '58	00.04	CST	Stroud 60 & Bandeen	
...ajun	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
...ajun	AM6.37	Churchill	24 Feb '58	01.35	CST	Spencer 58-1	
...ajun	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
...ajun	AM6.38	Churchill	24 Mar '58	12.30	CST	Spencer 58-1	

...from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

Altitude Range, Km

UPPER ATMOSPHERE
Measurements Reported

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
								ALTITUDE RANGE 80-90 Km.	
80.3	-	-	-	-	211.5	7.2	Grenade	Aerobee	SC-10
80.95	-	-	-	-	169	(P)	Alphatron*	Aerobee	31
82.4	$7.0x10^{-3}$	30	-	-	-	-	Phillips gage*	Aerobee	(nf)
83	-	-	$5.5x10^{-3}$	(p)	-	-	Ionization gage*	Nike-Cajun	AM6.38
[illegible]	$2.0x10^{-3}$	(p)	$3.0x10^{-3}$	(p)	309	(p)	Alphatron*	Aerobee	31
								ALTITUDE RANGE 90-100 Km.	
90	$3.0x10^{-4}$	(p)	-	-	-	-	Ionization gage*	V-2	15
90	-	-	-	-	130	(p)	Alphatron	V-2	20
90	-	-	-	-	200	40	Pirani gage*	V-2	21
90	$3.5x10^{-3}$	(nf)	-	-	220	(nf)	Pirani gage*	V-2	28
90	-	-	-	-	180	8.0	Grenade	Aerobee	SM2.06
90	-	-	$4.0x10^{-3}$	(nf)	-	-	Sphere*	Nike-Cajun	AM6.02
90	-	-	$1.9x10^{-3}$	(nf)	-	-	Sphere*	Aerobee	SM2.10
90	-	-	$4.2x10^{-3}$	(nf)	-	-	Sphere*	Nike-Cajun	AM6.03
90	-	-	$4.0x10^{-3}$	(nf)	-	-	Sphere*	Nike-Cajun	AM6.05
94	$1.2x10^{-3}$	(nf)	-	-	-	-	Phillips gage*	V-2	34

* These entries are taken from a published

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PHERE STRUCTURE DATA

Reported Through Early 1960

Project ARIES -- Contract Nonr 3071(00)

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
80-90 Km.							
	SC-10	WSPG	16 Oct '50	21.00	MST	Stroud 56	
	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	(p) preliminary see reference
	(nf)	WSPG	3 May '49	09.14	MST	Havens 52	(nf) not found
m	AM6.38	Churchill	24 Mar '58	12.30	CST	Spencer 58-1	
	31	Holloman	22 Oct '52	07.21	MST	Spencer 58-2	
90-100 Km.							
	15	WSPG	21 Nov '46	09.55	MST	Spencer 54	
	20	WSPG	20 Feb '47	11.16	MST	Spencer 54	
	21	WSPG	7 Mar '47	11.23	MST	Best 47	
	28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
	SM2.06	Churchill	25 Aug '57	08.08	CST	Stroud 60	
m	AM6.02	Churchill	25 Jan '58	13.12	CST	Jones 59	
	SM2.10	Churchill	27 Jan '58	12.48	CST	Jones 58	
m	AM6.03	Churchill	29 Jan '58	13.06	CST	Jones 59	
m	AM6.05	Churchill	4 Mar '58	13.30	CST	Jones 59	
	34	WSPG	22 Jan '48	13.13	MST	Havens 52 & LaGow 54	

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m a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

UPPER ATMOSPHERE STRUC

Measurements Reported Throu

Altitude	Pressure		Density		Temperature				
Km.	mm.Hg.	e.%	g/m³	e.%	°K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 100-110 Km.		
100	6.0×10^{-5}	(p)	-	-	-	-	Ionization gage*	V-2	15
100	-	-	-	-	190	(nf)	Alphatron	V-2	20
100	-	-	-	-	225	40	Phillips gage*	V-2	21
100	1.2×10^{-5}	(p)	-	-	228	(nf)	Pirani gage*	V-2	28
100	1.1×10^{-4}	30	2.3×10^{-4}	50	210	(nf)	Phillips gage*	Viking	7
100	-	-	-	-	198	(nf)	Phillips gage*	Aerobee-Hi	NN3.13
100	3.0×10^{-4}	20	7.2×10^{-4}	30	-	-	"	"	"
							ALTITUDE RANGE 110-120 Km.		
110	-	-	-	-	248	(p)	Alphatron	V-2	20
110	1.0×10^{-4}	10	-	-	275	40	Phillips gage*	V-2	21
110	1.4×10^{-4}	(nf)	2.0×10^{-4}	(nf)	-	-	Phillips gage*	V-2	34
110	2.6×10^{-5}	30	5.0×10^{-5}	50	228	(nf)	Ionization gage*	Viking	7
110	-	-	1.0×10^{-4}	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
110	-	-	-	-	230	(nf)	Phillips gages*	Aerobee-Hi	NN3.13
110	6.5×10^{-5}	20	1.3×10^{-4}	30	-	-	"	"	"
110	-	-	4.5×10^{-5}	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
115	-	-	-	-	1500	500	Langmuir Probe	Spaerobee	ABM10.S
118	-	-	-	-	1900	600	Langmuir Probe	Spaerobee	ABM10.S

* These entries are taken from a published

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Number	Place Fired	Date	Time	Zone	Reference Data	Notes
110 Km.						
15	WSPG	21 Nov '46	09.55	MST	Spencer 54	(p) preliminary see reference
20	WSPG	20 Feb '47	11.16	MST	Spencer 54	(nf) not found
21	WSPG	7 Mar '47	11.23	MST	Best 47	
28	WSPG	8 Dec '47	14.42	MST	Spencer 54	
7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	LaGow 58	
120 Km.						
20	WSPG	20 Feb '47	11.16	MST	Spencer 54	
21	WSPG	7 Mar '47	11.23	MST	LaGow 54	
34	WSPG	22 Jan '48	13.13	MST	Havens 52 & LaGow 54	
7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	LaGow 58	
NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
AM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59	
AM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59	

2

Altitude Range, Km

published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 120-130 Km.		
120	$3.5x10^{-5}$	10	-	-	-	-	Phillips gage*	V-2	21
120	-	-	-	-	335	40	"	"	"
120	$8.0x10^{-6}$	30	$1.2x10^{-5}$	50	270	(nf)	Ionization gage*	Viking	7
120	-	-	$2.9x10^{-5}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
120	-	-	-	-	370	(nf)	Phillips gage*	Aerobee-Hi	NN3.13F
120	$2.1x10^{-5}$	20	$2.6x10^{-5}$	30	-	-	"	"	"
120	-	-	$4.0x10^{-5}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18F
120	-	-	$1.0x10^{-5}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19F
120	-	-	$6.5x10^{-5}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
125	-	--	$1.0x10^{-5}$	(nf)	-	-	Phillips gage*	V-2	34
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							ALTITUDE RANGE 130-140 Km.		
130	$3.5x10^{-6}$	30	$3.3x10^{-6}$	50	428	(nf)	Ionization gage*	Viking	7
130	-	-	$6.0x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
130	-	-	-	-	950	(nf)	Phillips gage*	Aerobee-Hi	NN3.13F
130	$1.3x10^{-5}$	20	$6.4x10^{-6}$	30	-	-	"	"	"
130	-	-	$1.2x10^{-5}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18F
[illegible]	-	-	$3.0x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19F
130	-	-	$3.01x10^{-5}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
138	-	-	-	-	1800	600	Langmuir Probe	Spaerobee	AN10.2
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* These entries are taken from a published

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes	Altitude Range, Km
UDE RANGE 120-130 Km.								
V-2	21	WSPG	7 Mar '47	11.23	MST	LaGow 54		
"	"	"	"	"	"	Best 47		
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	(nf)- not found	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60		
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58		
"	"	"	"	"	"	LaGow 58		
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60		
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60		
(2) 1957α, 1957β		-	-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellites and carrier rockets.	
V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52		
UDE RANGE 130-140 Km.								
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57		
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60		
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58		
"	"	"	"	"	"	LaGow 58		
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60		
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60		
(2) 1957α, 1957β		-	-	-	-	Mikhnevich		
Spaerobee	AEM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59		

are taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

2

300 250 200 150 100 50 30

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UPPER ATMOSPHERE STRU(
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
							ALTITUDE RANGE 140-150 Km.		
140	-	-	$2.0x10^{-6}$	(nf)	-	-	Phillips gage*	V-2	34
140	$2.1x10^{-6}$	30	$1.2x10^{-6}$	50	700	(nf)	Ionization gage*	Viking	7
140	-	-	$1.2x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
140	-	-	-	-	1530	(nf)	Phillips gage*	Aerobee-Hi	NN3.13
140	$9.9x10^{-6}$	20	$3.0x10^{-6}$	30	-	-	"	"	"
140	-	-	$5.0x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
140	-	-	$1.1x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
140	-	-	-	-	1800	350	Langmuir Probe	Spaerobee	AB410.
140	-	-	$1.49x10^{-5}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
							ALTITUDE RANGE 150-160 Km.		
150	-	-	$2.0x10^{-6}$	(nf)	-	-	Phillips gage*	V-2	34
150	$1.5x10^{-6}$	30	$6.6x10^{-7}$	50	880	(nf)	Ionization gage*	Viking	7
150	-	-	$5.0x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
150	-	-	-	-	2050	(nf)	Phillips gage*	Aerobee-Hi	NN3.13
150	$8.2x10^{-6}$	20	$1.9x10^{-6}$	30	-	-	"	"	"
150	-	-	$5.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
150	-	-	$2.0x10^{-6}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
150	-	-	$8.07x10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
156	-	-	$2.0x10^{-6}$	50	-	-	Phillips Gage*	V-2	21

* These entries are taken from a publishe

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TUDE RANGE 140-150 Km.							
V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52 LaGow 54	(nf)- not found
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
Spaerobee	ABM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59	
(2) 1957α, 1957β	-		-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellite and carrier rockets.
TUDE RANGE 150-160 Km.							
V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52 and LaGow 54	
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
(2) 1957α, 1957β	-		-	-	-	Mikhnevich	
V-2	21	WSPG	7 Mar '47	11.23	MST	LaGow 54	

2

Altitude Range, Km

300
250
200
150
100
50
30

...re taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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UPPER ATMOSPHERE STRUC
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 160-170 Km.		
160	-	-	$1.5x10^{-6}$	(nf)	-	-	Phillips gage*	V-2	34
160	$1.1x10^{-6}$	30	$4.3x10^{-7}$	50	980	(nf)	Ionization gage*	Viking	7
160	-	-	$1.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
160	-	-	-	-	2470	(nf)	Phillips gage*	Aerobee-Hi	NN3.1
160	$7.1x10^{-6}$	20	$1.4x10^{-6}$	30	-	-	"	"	"
160	-	-	$8.0x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
160	-	-	$3.0x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
160	-	-	-	-	1900	500	Langmuir Probe	Spaerobee	ABM10.
160	-	-	$4.7x10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
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							ALTITUDE RANGE 170-180 Km.		
170	$8.6x10^{-7}$	30	$3.0x10^{-7}$	50	1050	(nf)	Ionization gage*	Viking	7
170	-	-	$8.0x10^{-8}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
170	-	-	-	-	2750	(nf)	Phillips gage*	Aerobee-Hi	NN3.1
170	$6.3x10^{-6}$	20	$1.1x10^{-6}$	30	-	-	"	"	"
170	-	-	$4.0x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
170	-	-	$1.9x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
170	-	-	$2.89x10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
178	-	-	-	-	1400	400	Langmuir Probe	Spaerobee	ABM10.2
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* These entries are taken from a published

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Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TUDE RANGE 160-170 Km.							
V-2	34	WSPG	22 Jan '48	13.13	MST	Havens 52 LaGow 54	(nf)- not found
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
Spaerobee	ABM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59	
(2) 1957α, 1957β		-	-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellites and carrier rockets.

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
TUDE RANGE 170-180 Km.							
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
(2) 1957α, 1957β		-	-	-	-	Mikhnevich	
Spaerobee	ABM10.200	Churchill	30 Nov '58	12.36	CST	Boggess 59	

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UPPER ATMOSPHERE STRUC
Measurements Reported Throu

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Number
							ALTITUDE RANGE 180-190 Km.		
180	$6.9x10^{-7}$	30	$2.3x10^{-7}$	50	1070	(nf)	Ionization gage*	Viking	7
180	-	-	$5.5x10^{-8}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
180	-	-	-	-	2940	(nf)	Phillips gage*	Aerobee-Hi	NN3.1[illegible]
180	$5.7x10^{-6}$	20	$8.9x10^{-7}$	30	-	-	"	"	"
180	-	-	$2.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
180	-	-	$1.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.19
180	-	-	$1.87x10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
186	-	-	$6.7x10^{-7}$	(nf)	-	-	Satellite drag	1958α	-
							ALTITUDE RANGE 190-200 Km.		
190	$5.5x10^{-7}$	30	$1.8x10^{-7}$	50	1070	(nf)	Ionization gage*	Viking	7
190	-	-	$4.0x10^{-8}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.17
190	-	-	-	-	2970	(nf)	Phillips gage*	Aerobee-Hi	NN3.1[illegible]
190	$5.1x10^{-6}$	20	$7.9x10^{-7}$	30	-	-	"	"	"
190	-	-	$2.0x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-Hi	NN3.18
190	-	-	$1.25x10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
197	-	-	$7.0x10^{-7}$	(nf)	-	-	Satellite drag	1957β	-

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* These entries are taken from a published

SPHERE STRUCTURE DATA
Reported Through Early 1960

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
E RANGE 180-190 Km.							
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	(nf)- not found
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-Hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
(2) 1957α, 1957β		-	-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellites and carrier rockets.
1958α	-	-	-	-	-	Schilling 59	
E RANGE 190-200 Km.							
Viking	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
Aerobee-Hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
Aerobee-Hi	NN3.13F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
"	"	"	"	"	"	LaGow 58	
Aerobee-Hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
(2) 1957α, 1957β		-	-	-	-	Mikhnevich	
1958δ	-	-	-	-	-	Schilling 59	

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taken from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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UPPER ATMOSPHERE STRU
Measurements Reported Thro

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numb
							ALTITUDE RANGE 200-210 Km.		
200	$4.2x10^{-7}$	30	$1.4x10^{-7}$	50	1070	(nf)	Ionization gage*	Viking	7
200	-	-	$2.5x10^{-8}$	25	-	-	Mass Spectrometer	Aerobee-hi	NN3.1
200	-	-	-	-	3010	(nf)	Phillips gage*	Aerobee-hi	NN3.1
200	$4.6x10^{-6}$	20	$7.0x10^{-7}$	30	-	-	"	"	"
200	-	-	$1.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-hi	NN3.1
200	-	-	$3-8.63x10^{-7}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
201	-	-	$6.7x10^{-7}$	(nf)	-	-	Satellite Orbits	1957β	-
							ALTITUDE RANGE 210-220 Km.		
210	$3.3x10^{-7}$	30	$1.1x10^{-7}$	50	1070	(nf)	Ionization	Viking	7
210	-	-	$3.2x10^{-8}$	25	-	-	Mass Spectrometer	Aerobee-hi	NN3.17
210	-	-	-	-	3050	(nf)	Phillips gage*	Aerobee-hi	NN3.1
210	$4.1x10^{-6}$	20	$6.2x10^{-7}$	30	-	-	"	"	"
210	-	-	$1.5x10^{-7}$	25	-	-	Mass Spectrometer	Aerobee-hi	NA3.1
210	-	-	$6.04x10^{-7}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
211	-	-	$4.6x10^{-7}$	(nf)	-	-	Satellite drag	1957β	-
211	-	-	$4.6x10^{-7}$	(nf)	-	-	Satellite Orbits	1957α 2	-
212	-	-	$4.8x10^{-7}$	(nf)	-	-	Satellite drag	1957β 1	-
215	-	-	$1.0x10^{-7}$	(nf)	-	-	Mass Spectrometer	Aerobee-hi	NN3.1

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* These entries are taken from a publishe

icle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
ANGE 200-210 Km.							
ing	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	(nf) - not found
obee-hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
obee-hi	NN3.15F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
	"	"	"	"	"	LaGow 58	
obee-hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
1957α, 1957β		-	-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellite and carrier rockets.
7β	-	-	-	-	-	Schilling 59	
———	———	———	———	———	———	———	
———	———	———	———	———	———	———	
ANGE 210-220 Km.							
ng	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	
bee-hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	
bee-hi	NN3.15F	Churchill	29 Jul '57	15.59	CST	Horowitz 58	
	"	"	"	"	"	LaGow 58	
bee-hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
1957α, 1957β		-	-	-	-	Mikhnevich	
β	-	-	-	-	-	Schilling 59	
α 2	-	-	-	-	-	Schilling 59	
β 1	-	-	-	-	-	Schilling 59	
bee-hi	NN3.18F	Churchill	21 Feb '58	20.02	CST	Meadows 60	
———	———	———	———	———	———	———	
———	———	———	———	———	———	———	

2

n from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

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ALTITUDE RANGE 220-230 Km.

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
220	2.7×10^{-8}	30	9.0×10^{-8}	50	1070	(nf)	Ionization gage*	Viking	:
220	-	-	$3.5-3.7 \times 10^{-6}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
220	-	-	4.0×10^{-7}	(nf)	-	-	Satellite Orbits	1957α 2	-
220	-	-	5.7×10^{-7}	(nf)	-	-	Satellite Orbits	1957α 1	-
220	-	-	4.5×10^{-7}	(nf)	-	-	Satellite Orbits	1957α 2	-

* These entries are taken from a publishe

ALTITUDE RANGE 230-240 Km.

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
230	-	-	3.32×10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
230	5.54×10^{-7}	(nf)	1.79×10^{-7}	(nf)	938	(nf)	Discharge Manometer	1957δ	-
232	-	-	1.5×10^{-7}	(nf)	-	-	Satellite Orbits	1957α 2	-
233	-	-	2.2×10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957β	-
233	-	-	2.2×10^{-7}	(nf)	-	-	Satellite drag	1957β 1	-

1

ALTITUDE RANGE 240-250 Km.

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
240	-	-	2.51×10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
240	1.42×10^{-7}	(nf)	-	-	946	(nf)	Discharge Manometer	1957δ	-
241	-	-	2.5×10^{-7}	(nf)	-	-	Satellite Orbits	1957α 2	-

220-230 Km.

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
B	7	WSPG	7 Aug '51	11.00	MST	Horowitz 57	(nf)- not found
1957α, 1957β		-	-	-	-	Mikhnevich	Entries marked with (2) are based on drag data for satellite and carrier rockets.
2	-	-	-	-	-	Schilling 59	
1	-	-	-	-	-	Sterne 58	
2	-	-	-	-	-	Sterne 58	

from a published curve. Interpolation for tabular presentation may have introduced an error of ± 5%.

230-240 Km.

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957α, 1957β		-	-	-	-	Mikhnevich	
5	-	-	-	-	-	Mikhnevich	
2	-	-	-	-	-	Schilling 59	
1957β	-	-	-	-	-	Sterne 58	
1	-	-	-	-	-	Schilling 59	

240-250 Km.

	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957α, 1957β		-	-	-	-	Mikhnevich	
	-	-	-	-	-	Mikhnevich	
2	-	-	-	-	-	Schilling 59	

Altitude Range, Km.
300
250
200
150
100
50
30

2

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Measurements Reported Thro

Altitude Km.	Pressure mm.Hg.	e.%	Density g/m³	e.%	Temperature °K	e. °K	Instrumentation	Vehicle	Numbe
							ALTITUDE RANGE 250-260 Km.		
250	-	-	1.1-1.9x10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
250	3.54x10^{-7}	(nf)	1.1x10^{-7}	(nf)	958	(nf)	Discharge Manometer	1957δ	-
							ALTITUDE RANGE 260-270 Km.		
260	-	-	1.51x10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
260	2.88x10^{-7}	(nf)	8.66x10^{-8}	(nf)	971	(nf)	Discharge Manometer	1957δ	-
							ALTITUDE RANGE 270-280 Km.		
270	-	-	1.19x10^{-7}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
270	2.35x10^{-7}	(nf)	6.83x10^{-8}	(nf)	987	(nf)	Discharge Manometer	1957δ	-
275	-	-	8.5x10^{-8}	(nf)	-	-	Satellite Orbits	1957α2	-
							ALTITUDE RANGE 280-290 Km.		
280	-	-	9.51x10^{-8}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
280	1.95x10^{-7}	(nf)	5.44x10^{-8}	(nf)	1005	(nf)	Discharge Manometer	1957δ	-

1

-260 Km.

Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957 β	-	-	-	-	Mikhnevich	(nf) - not found Entries marked with (2) are based on drag data for satellites and carrier rockets.
-	-	-	-	-	Mikhnevich	
———	———	———	———	———	———	
———	———	———	———	———	———	

-270 Km.

Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957 β	-	-	-	-	Mikhnevich	
-	-	-	-	-	Mikhnevich	
———	———	———	———	———	———	
———	———	———	———	———	———	

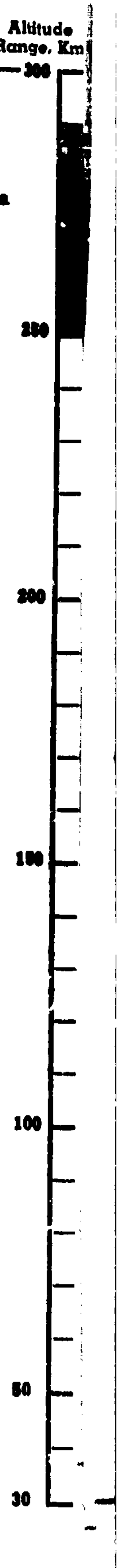
-280 Km.

Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957 β	-	-	-	-	Mikhnevich	
-	-	-	-	-	Mikhnevich	
-	-	-	-	-	Schilling	
———	———	———	———	———	———	
———	———	———	———	———	———	

2

290 Km.

Number	Place Fired	Date	Time	Zone	Reference Data	Notes
1957 β	-	-	-	-	Mikhnevich	
-	-	-	-	-	Mikhnevich	
———	———	———	———	———	———	
———	———	———	———	———	———	



UPPER ATMOSPHERE STRU
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Altitude	Pressure		Density		Temperature				
Km.	mm.Hg.	e.%	g/m³	e.%	°K	e. °K	Instrumentation	Vehicle	Numbe
								ALTITUDE RANGE 290-300 Km.	
290	-	-	7.68×10^{-8}	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
290	1.62×10^{-7}	(nf)	4.36×10^{-8}	(nf)	1026	(nf)	Discharge Manometer	1957δ	-
								ALTITUDE RANGE 300-310 Km.	
300	-	-	$5-6.27 \times 10^{-8}$	(nf)	-	-	Satellite Orbits	(2) 1957α, 1957β	
300	1.37×10^{-7}	(nf)	3.53×10^{-8}	(nf)	1048	(nf)	Discharge Manometer	1957δ	-

1

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Notes
ITUDE RANGE 290-300 Km.							
(2) 1957α, 1957 β		-	-	-	-	Mikhnevich	(nf)- not found Entries marked with (2) are based on drag data for satellites and carrier rockets.
ter 1957 δ	-	-	-	-	-	Mikhnevich	
ITUDE RANGE 300-310 Km.							
(2) 1957α, 1957 β		-	-	-	-	Mikhnevich	
ter 1957 δ	-	-	-	-	-	Mikhnevich	

Altitude Range, Km

300

250

200

150

100

50

30

2

Altitude Km.	Composition/Component			Instrumentation	Vehicle	Number
	Ratio, relative to N					
	He	Ne	A			
57.4	0.998	1.005	1.001	Sampling	Aerobee	SC-21
59.7	1.035	1.008	0.996	"	"	"
62.3	1.133	1.040	0.962	"	V-2	59
65.6	1.44	1.08	0.93	"	Aerobee	SC-17
68.3	2.02	1.18	0.89	"	"	"
69.8	1.570	1.232	0.90	"	V-2	59
70.6	2.41	1.20	0.85	"	Aerobee	SC-17
82.5	3.14	1.34	-	"	"	SC-34
83.4	2.943	1.395	0.82	"	V-2	59
	Separation Ratios					
120	0.98			Radio frequency Mass Spectrometer	Aerobee-hi	NN3.19F
120	0.42			"	"	NN3.17
130	0.60			"	"	NN3.19F
130	0.45			"	"	NN3.18F
130	0.30			"	"	NN3.17
140	0.40			"	"	NN3.19F
140	0.30			"	"	NN3.18F
140	0.20			"	"	NN3.17
150	0.30			"	"	NN3.19F
150	0.20			"	"	NN3.18F
150	0.20			"	"	NN3.17
160	0.30			"	"	NN3.19F

1

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Remarks
Aerobee	SC-21	WSPG	26 Sep '51	-	-	Jones 54	
"	"	"	"	-	-	"	
V-2	59	"	20 May '52	-	-	"	Recovered sample bottles were analyzed in laboratory for amount of Helium, Neon, and Argon relative to Nitrogen. These results were compared with the relative concentration of the gases at sea level.
Aerobee	SC-17	"	19 Dec '50	-	-	"	
"	"	"	"	-	-	"	
V-2	59	"	20 May '52	-	-	"	
Aerobee	SC-17	"	19 Dec '50	-	-	"	
"	SC-34	"	9 Aug '56	08.53	MST	Wenzel 58	
V-2	59	"	20 May '52	-	-	Jones 54	
Aerobee-hi	NN3.19F	Churchill	23 Mar '58	12.07	CST	Meadows 60	
"	NN3.17	"	20 Nov '56	23.21	"	"	
"	NN3.19F	"	23 Mar '58	12.07	"	"	Separation Ratio based on: $\frac{\text{Argon/molecular Nitrogen at altitude}}{\text{Argon/molecular Nitrogen at sea level}}$
"	NN3.18F	"	21 Feb '58	20.02	"	"	
"	NN3.17	"	20 Nov '56	23.21	"	"	
"	NN3.19F	"	23 Mar '58	12.07	"	"	
"	NN3.18F	"	21 Feb '58	20.02	"	"	
"	NN3.17	"	20 Nov '56	23.21	"	"	
"	NN3.19F	"	23 Mar '58	12.07	"	"	
"	NN3.18F	"	21 Feb '58	20.02	"	"	
"	NN3.17	"	20 Nov '56	23.21	"	"	
"	NN3.19F	"	23 Mar '58	12.07	"	"	

2

Altitude Km.	Composition/Component			Instrumentation	Vehicle	Number
	Mean Molecular Weight					
	NN3.17	NN3.18	NN3.19			
135	28.2	28.2	28.6	Mass Spectrometer	Aerobee-hi	NN3.17
140	27.9	28.1	28.6	Mass Spectrometer	Aerobee-hi	NN3.18
150	27.8	-	28.2	Mass Spectrometer	Aerobee-hi	NN3.19
160	27.8	-	-			
170	27.8	27.5	27.5			
180	-	27.5	27.5			
190	-	27.5	27.2			
200	-	26.7	-			
210	-	26.8	-			
220	-	25.8	-			

1

Vehicle	Number	Place Fired	Date	Time	Zone	Reference Data	Remarks
Aerobee-hi	NN3.17	Churchill	20 Nov '56	23.21	CST	Meadows 60	Data from curve. See reference, figure 7.
Aerobee-hi	NN3.18	Churchill	21 Feb '58	20.02	CST	Meadows 60	
Aerobee-hi	NN3.19	Churchill	23 Mar '58	12.07	CST	Meadows 60	

2

Altitude Km.	Composition/Component	Instrumentation	Vehicle	Number
	Ozone, Molecules/cc			
30	$5.0x10^{12}$	U. V. Spectrograph	-	-
40	$5.0x10^{11}$	"	-	-
50	$8.0x10^{10}$	"	-	-
60	$9.0x10^{9}$	"	-	-
70	$9.0x10^{8}$	"	-	-
	% Dissociation of O_2			
120	67	Photon Counters	Aerobee	A-35
130	65	"	"	"
160	70	"	"	"
	Oxygen Molecules/cc			
110	$16.0x10^{10}$	Photon Counter	Aerobee	A-16
114	$12.0x10^{10}$	"	"	A-34
116	$9.0x10^{10}$	"	"	"
118	$2.3x10^{10}$	"	"	"
120	$1.8x10^{10}$	"	"	"
120	$3.0x10^{10}$	"	"	A-16
130	$1.0x10^{10}$	"	"	"
150	$4.0x10^{9}$	"	"	A-35
160	$1.4x10^{9}$	"	"	"
170	$8.0x10^{8}$	"	"	"
180	$4.0x10^{8}$	"	"	"

1

Number	Place Fired	Date	Time	Zone	Reference Data	Remarks
-	WSPG	14 Jun '49	7.05	MST	Johnson 54	
-	"	"	"	"	"	
-	"	"	"	"	"	
-	"	"	"	"	"	
-	"	"	"	"	"	
A-35	-	21 Oct '55	17.15	-	Byram 57	Dissociation based on density of molecular Oxygen measured by ultraviolet absorption relative to density of Air at altitude, measured by x-ray absorption.
"	-	"	"	-	"	
"	-	"	"	-	"	
A-16	-	1 Dec '53	08.29	-	Byram 57	
A-34	-	18 Oct '55	15.50	-	"	
"	-	"	"	-	"	
"	-	"	"	-	"	
"	-	"	"	-	"	Based on 44-60 Å absorption of Molecular Oxygen at altitude.
A-16	-	1 Dec '53	08.29	-	"	
"	-	"	"	-	"	
A-35	-	21 Oct '55	17.15	-	"	
"	-	"	"	-	"	
"	-	"	"	-	"	
"	-	"	"	-	"	

Altitude Km.	Composition/Component			Instrumentation	Vehicle	Number
	Ion Detected Mass					
100	46^-			Ion Spectrometer	Aerobee	NRL-24
110	"			"	"	"
120	"			"	"	"
130	"			"	"	"
	Ion Detected Mass					
100	28^+			Ion Spectrometer	Aerobee	NRL-2[illegible]
110	"			"	"	"
115	"			"	"	"
	Mass Peaks					
115	$30^+;26^+$	32^+	16^+	Ion Spectrometer	Viking	10
150	"	"	"	"	"	"
220	"	"	"	"	"	"
	Ratio of Ion Peak Currents N^+/O^+, Per Cent					
220-240		$9\text{-}2^{(b)}$		Mass Spectrometer	1958 α	-
250-270		$4\text{-}2^{(a)}$		"	"	-

1

le	Number	Place Fired	Date	Time	Zone	Reference Data	Remarks
bee	NRL-24	WSPG	29 Nov '57	10.16	MST	Johnson 58	See paper for discussion of relative amplitudes of atomic mass units.
	"	"	"	"	"	"	
	"	"	"	"	"	"	
	"	"	"	"	"	"	
bee	NRL-23	WSPG	8 Jul '55	01.39	MST	Johnson 58	" " "
	"	"	"	"	"	"	
	"	"	"	"	"	"	
G	10	WSPG	7 May '54	10.00	MST	Johnson 55	
	"	"	"	"	"	"	
	"	"	"	"	"	"	
k	-	-	22 May '58	-	-	Istomin	From curve of changing relative intensity. Ratios are also affected by latitude. (a) North latitudes (b) South latitudes
	-	-	"	-	-	"	

2

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Properties of the Upper Atmosphere

APPENDIX A

Meteorological Instrumentation Employed for Pressure, Temperature, Density, and Composition

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Contract Nonr 3071(00)
Final Report
1 August 1960

THE DOVAP SYSTEM FOR ROCKET ALTITUDE MEASUREMENT

The DOVAP (Doppler Velocity And Position) system is used to determine the altitude and trajectory of research rockets. The system is represented schematically in Figure 1.

The ground transmitter radiates a signal on a reference frequency. This signal is received by both the tracking receivers and the rocket vehicle. A transponder in the rocket vehicle retransmits the reference signal at double the reference frequency. This signal is compared to the original reference signal also received at each of the tracking stations. The Doppler shift of the rocket's signal will be a function of the velocity of the rocket, and the altitude and azimuth of the incoming signal from the rocket determine the position of the transponder and its rocket vehicle.

The DOVAP system operates with an accuracy of ±1 foot in position and 1 foot-second in velocity.

Literature Citation:

Massey, H.S.W., and R.L.F. Boyd, The Upper Atmosphere, pp. 66-70, Philosophical Library, New York, N. Y. 1959.

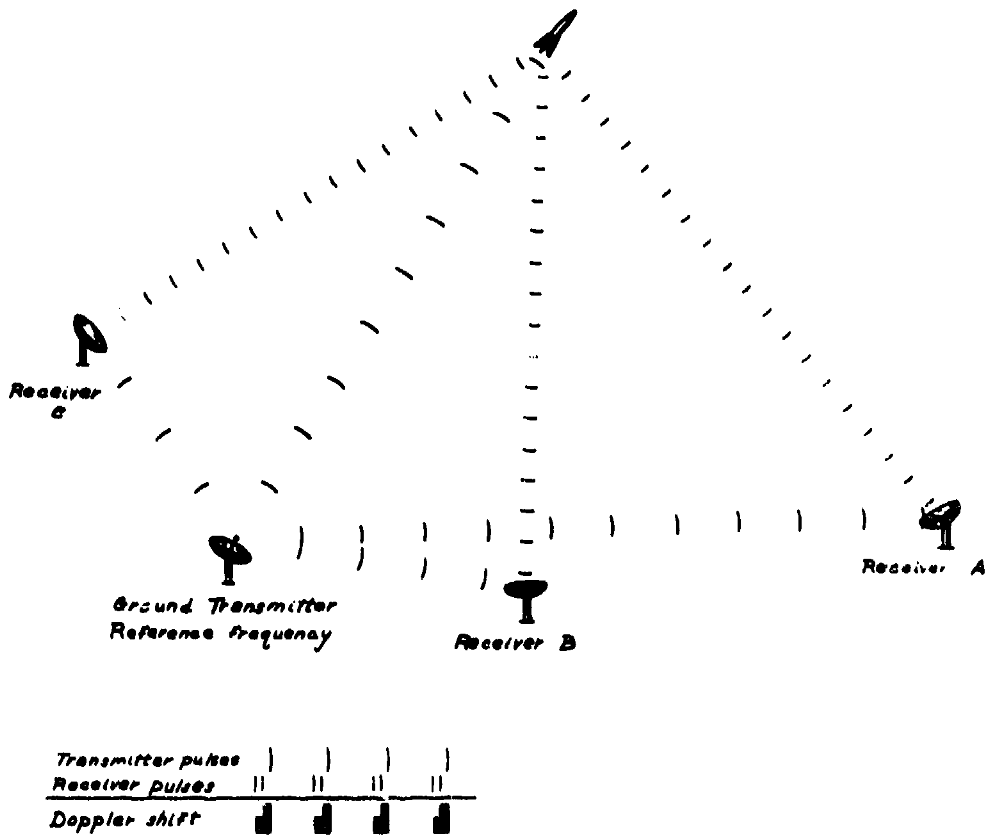
Receiver C
Ground Transmitter
Reference frequency
Receiver B
Receiver A
Transmitter pulses
Receiver pulses
Doppler shift

Figure 1

IONIZATION GAGES
(Alphatron)

Ionization gages measure the number of free ions produced by a flow of electrons in a diffuse gas. The relative number of free ions formed by a constant electron source is a function of the density and composition of the gas within the ionization gage.

The Alphatron is typical of the radioactive, cold-cathode type of ionization gage. A radioactive isotope within the gage provides a constant source of ionizing radiation. The instrument is essentially a modification of the electrostatic detectors used to count radioactive particles.

In the operating instrument (see Figure 2) a voltage is applied to both the wall and wire electrode of the gage. Gas atoms entering the gage are ionized by the radioactive isotope, and the ionized gas atoms are then attracted to the wall of the gage. The drift of these ionized particles lowers the voltage between the two charged elements of the gage. When this voltage drops to a pre-set point, the chamber is redharged to its original voltage. The frequency of recharge is proportional to the rate of ion formation.

The use of ionization gages of the Alphatron type is based on the following assumptions:

The devices are insensitive to acceleration changes.

They provide rapid discrete responses to density changes of a homogenous medium.

By suitably switching the voltage drops for recharging the instrument, it can be used to measure density directly to altitudes of about 200 kilometers.

Sources of error in the technique include:

The devices measure only the <u>relative</u> number of ions formed.

Ion formation is affected by the composition as well as the density of the gas being measured (see Figure 3).

Ionization Gage (cont.)

External ion sources (e.g., the ions in the F and D layers of the upper atmosphere) will interfere with the ion counts obtained by the instrument.

Gas density is temperature dependent.

The instrument may not be at temperature equilibrium with the atmosphere.

Density measurements are probably correct to within an order of magnitude up to 250 kilometers.

Literature Citations:

LaGow, H., "Arctic Atmosphere Structure to 250 Km," IGY Rocket Report Series, No. 1., pp. 38-46, 30 July 1958.

Non-N 60921-5608, Wright Instruments, Inc., " A Survey of Pressure and Density Sensors and Associated Problems for the N. O. L. HASP Program," April 1959.

Spencer, N. W. and W. G. Dow, " Density Gauge Methods for Measuring Upper-Air Temperature, Pressure, and Winds," Rocket Exploration of the Upper Atmosphere, pp. 82-97, Permagon Press Ltd., London, 1954.

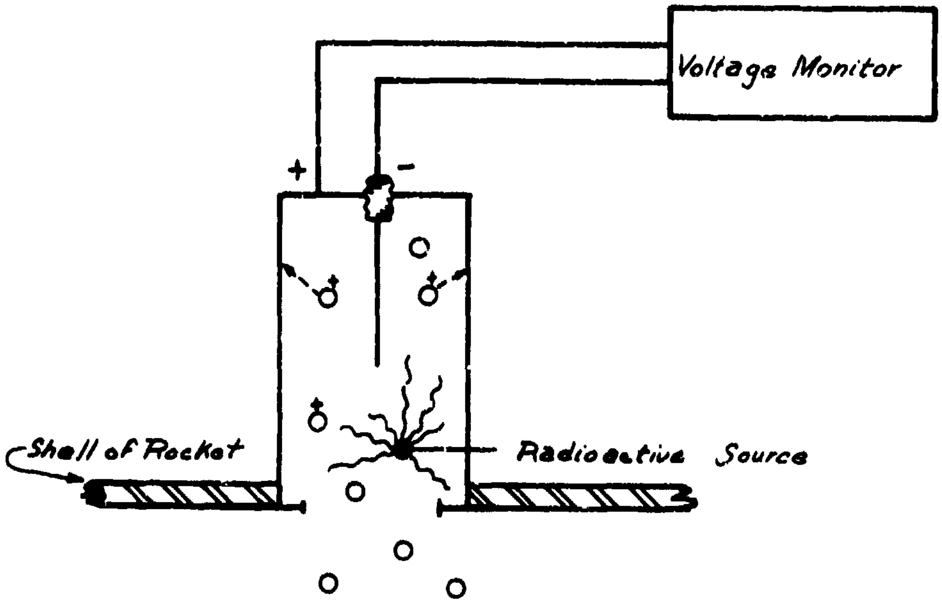

Figure 2

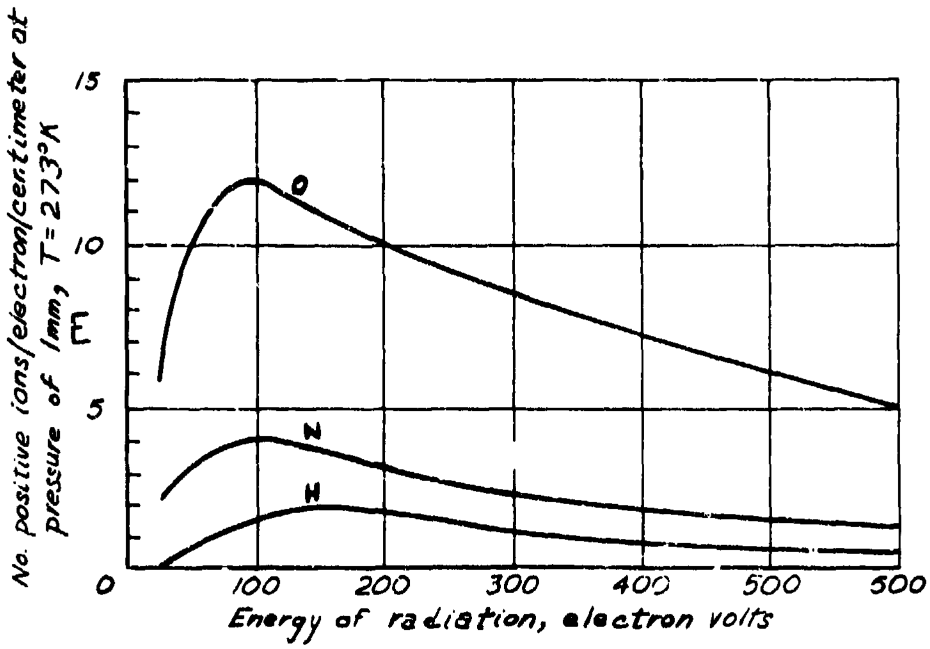

Figure 3

THERMAL CONDUCTIVITY GAGES
(Pirani Gage, Havens Gage)

Pirani Gage

Thermal conductivity, or Pirani gages, measure pressure by monitoring the resistance change of a heated wire element. Changes in air pressure surrounding the wire element change the rate at which heat is lost by the element. Pirani gages are commercially available which measure pressure down to 10^{-3} mm/Hg.

Havens Gage

The Havens gage, developed at the Naval Research Laboratory, is a modification of the thermal conductivity gage. It measures pressures down to 10^{-5} mm/Hg.

The gage works on the principle that an alternating current signal can be obtained from the normally direct-current Pirani gage by cyclically changing the pressure at a given frequency. At low ambient pressures, the compression of the bellows does not affect the temperature of the gas within the bellows significantly. The cylical changes of the bellows will result in alternating voltage output from the resistance element, and the amplitude of the alternating voltage will be proportional to the change in ambient pressure. The eccentric shaft of the small motor, Figure 4, changes the volume of the bellows about 20 per cent at a frequency of about 20 cycles per second.

The use of two bellows assures that the eccentric shaft is working against the same pressure in each bellow, regardless of the outside pressure. The outside pressure is communicated to the pressure chambers by small holes which restrict the rate of gas flow so that the gas does not flow completely out of the chamber when the bellows are compressed. Since the pressure inside the bellows chamber is changed about 40 times per second, the average pressure within the bellows will be at equilibrim with the outside pressure. The peak-to-peak alternating voltage developed across the resistance elements within the bellows will vary directly with the outside pressure. At a pressure of 0.6 mm/Hg, a change of

Thermal Conductivity Gages (cont.)

20 percent in the bellows pressure changes the voltage across the resistance by 0.27 volts. Figure 5 is a schematic of the calibration curve for a bellows gage in which the pressure is changing about 40 times per second.

Pressure measdurements by thermal conductivity gages are subject to error due to the variation of atmospheric composition, with the resulting variations of specific heat of the gas surrounding the heated wire.

Literature Citations:

Havens, R., R. Koll, and H. LaGow, "A New Vacuum Gauge," Rev. Sci. Instr., 21, 596-598 (1950).

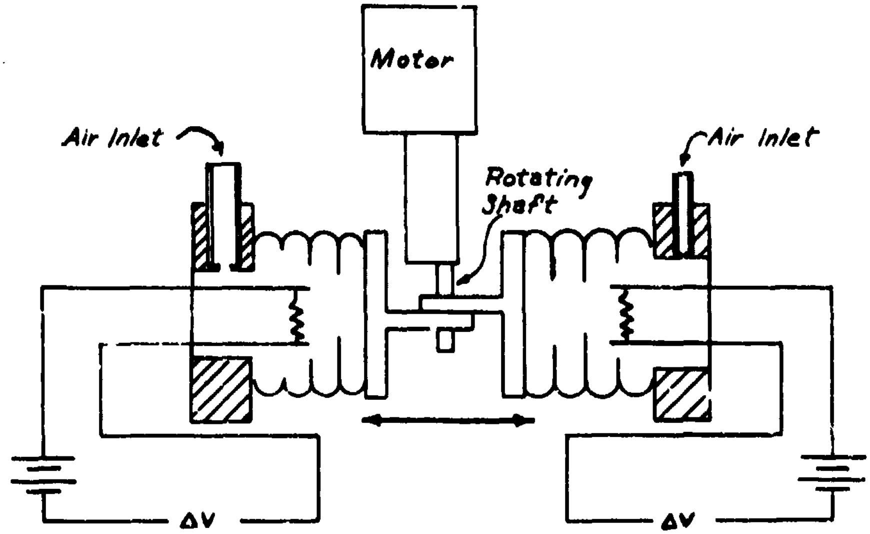

Figure 4

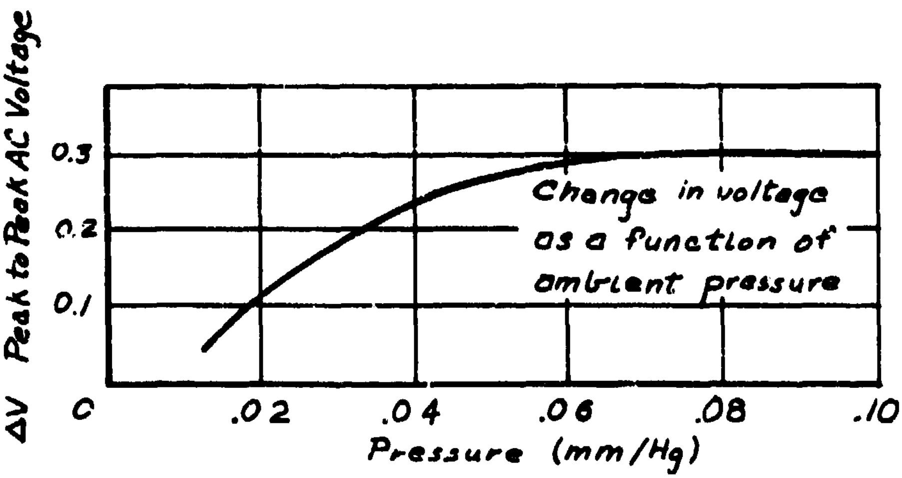

Figure 5

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Final Report
1 August 1960

THE FALLING SPHERE

The technique of measur ing the drag on a falling sphere, ejected from a rocket at peak altitude, to obtain upper air density and temperature was developed at the University of Michigan. The most recent form of the experiment uses a small sphere about seven inches in diameter.

Air density of the atmosphere is calculated from the velocity of the falling sphere using the drag equation:

$$\rho = \frac{2\, m\, a_D}{V^2\, A\, C_D}$$

ρ = density
m = mass of sphere
a_D = drag acceleration
V = velocity of sphere
A = cross-sectional area of sphere
C_D = coefficient of drag of sphere

Pressure and temperature at altitude are derived from the drag data by substitution in the hydrostatic equation:

$$T_h = \frac{\int_h^{h_o} P\, h\, g\, d\, h}{P\, h\, \frac{R}{M}} + \frac{P_o}{P_h}\, T_o$$

T = temperature $^\circ$kelvin
P = density
g = acceleration of gravity
h = altitude
R = gas constant
M = molecular weight of air

An initial temperature is assumed for the begining of the trajectory.

Early versions of the falling sphere experiment relied on Doppler radar tracking to derive the trajectory of the falling sphere. The more recent versions include an accelerometer and telemetering transmitter within the sphere to measure and transmit the drag acceleration from the sphere.

The Falling Sphere (cont.)

The falling sphere experiment for determining atmospheric parameters is based on the following assumptions:

1. The hydrostatic barometric equation is valid for the region of the sphere trajectory.
2. The atmospheric composition is constant, and its mean molecular weight is fixed.

Possible errors for this method include:

1. The neglect of winds in the trajectory calculations.
2. The errors of measurement of the drag acceleration and the coefficient of drag for the sphere.
3. Possible errors in the calculation of the trajectory.

In addition, the assumed temperature at the begining of the trajectory introduces a possible error in the first 15 kilometers of the trajectory.

Literature Citation:

Bartman, F.L., "The Falling Sphere for Upper Air Density and Temperature," Rocket Exploration of the Upper Atmosphere, R.L.F. Boyd and M.J. Seaton, editors, Pergamon Press, Ltd., London, 1954.

Jones, L.M., "Upper-Air Density and Temperature: Some Variations and Abrupt Warming in the Mesosphere," J. Geophys. Res., 64, 2331-40 (1959).

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THE GRENADE EXPERIMENT

The grenade experiment is based on measuring the average velocity of sound, traveling to the ground, when produced by a grenade exploded at various altitudes. The atmospheric temperature in the region of the grenade explosion is determined by the variation of sound velocity with the altitude of the grenade explosion. A schematic of the experiment is outlined in Figure 6.

The velocity of sound is calculated thus:

$$C = \sqrt{\frac{\gamma R}{M} T}$$

$$\frac{\gamma R}{M} = K \quad \text{(constant)}$$

Thus: $C = \sqrt{KT}$

C = velocity of sound, dry air
γ = ratio of specific heats of air
R = gas constant
T = temperature °kelvin
M = molecular weight of air

The average temperature of the region between two grenade explosions is calcualted from the variation of the sound velocity from these explosions. Wind effects on the path of sound transmission are determined by a sound-ranging network which measures the directional position of the sound wave arriving on the ground. This direction yields the apparent position of the grenade explosion which is then compared with the true position, obtained by a DOVAP telemetering device.

The use of the grenade experiment for determining atmospheric temperature is based on the following assumptions:

1. Vertical wind components are negligible compared with acoustic velocity in the region of measurement.
2. The composition of the atmosphere is constant up to about 90 kilometers, the region measured by the experiment.

The Grenade Experiment (cont.)

The calculation for the experiment yield only the average temperature in the layer at which the grenade is detonated. This average temperature is assumed to exist throughout the layer.

Possible errors for the grenade experiment include:

1. Variations with altitude of the specific heat or water vapor of the atmosphere introduce errors in the calculation of temperature, from the above equation.
2. The accuracy of the measurements is limited by the sound-ranging network's accuracy to determine the time of arrival of the sound waves at the individual microphones.
3. The grenade experiment is probably accurate to about 5^{0} for determination of temperature to an altitude of about 90 kilometers. Above about 95 kilometers, sound waves cannot be generated with sufficient energy to reach ground stations.

Literature Citations:

Stroud, W.G., W.R. Bandeen, W. Nordberg, F.L. Bartman, J. Otterman, and P. Titus, "Temperature and Winds in the Arctic Obtained by the Rocket Grenade Experiment," IGY Rocket Report Series, 1, pp. 58-79, July 1958.

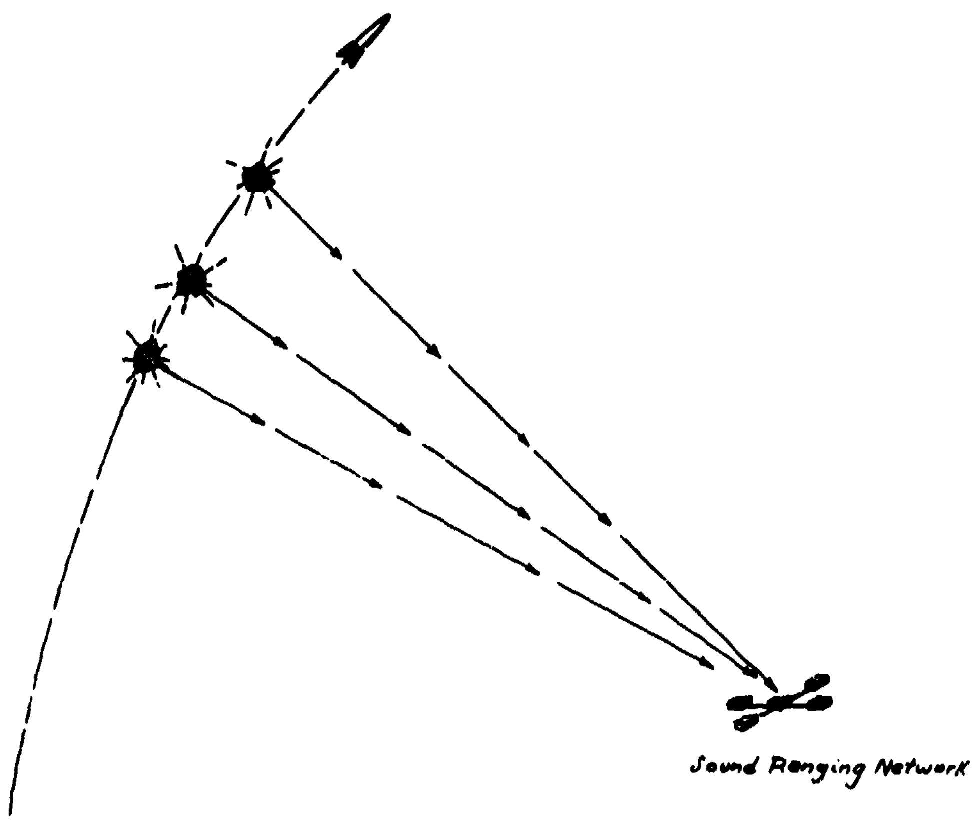

Figure 6

THE COMPOSITION-MASS SPECTROMETER

The Bennet radio-frequency mass spectrometer can be used to obtain spectra of atmospheric composition above 100 kilometers. A diagram of the device is shown in Figure 7. Ions are formed by the bombardment of air molecules with 45-volt electrons in the ion cage. These ions, drawn out and collimated by grids at points 3 and 4, are accelerated by a negative sweep potential into the analyzer section. This negative sweep potential is modified by a small constant-bias voltage applied to grids at points 5 and 7. Ions not receiving the maximum incremental energy per state in the analyzer are turned back by a positive stopping potential applied to grid at point 8. The desired ions have sufficient energy to overcome this positive potential and reach the collector.

The mass of the ions arriving in the collecting assembly can be represented as follows:

$$M = \frac{0.266\ V}{s^2\ f^2}$$

M = mass in atomic mass units

s = spacing between grids of anlyzer section in centimeters.

f = frequency in megacyles

V = voltage

Variation of either frequency or voltage will sweep the tube over a range of atomic mass units. The sweep rate is limited to the frequency response of the telemetering system in use. With a radio-frequency of 3.9 megacyles and a sweep varying between -250 and -25 volts, the instrument will cover the range between 48 and 5 atomic mass units.

Literature Citation:

Townsend, J.W., JR., Radiofrequency Mass Spectrometer for Upper Air Research, Naval Research Laboratory, Washington 20, D.C., 8 January 1952.

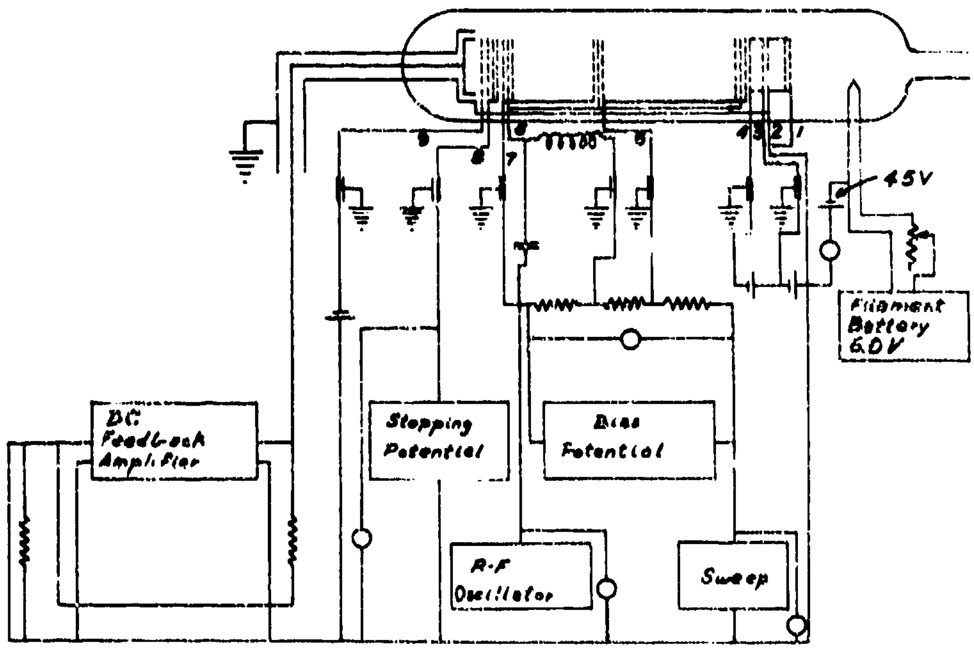
45V
Filament Battery 6.0V
DC Feedback Amplifier
Stopping Potential
Bias Potential
R-F Oscillator
Sweep

Figure 7

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APPENDIX B

Abstract Bibliography of Data Sources

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Upper Atmosphere Structure Data

REFERENCES

Bandeen

Bandeen, W.R., Griffith, R.M., Nordberg, W., Stroud, W.G., The Measurement of Temperatures, Densities, Pressures and Wins over Fort Churchill, Canada, by means of The Rocket Grenade Experiment, USASRDL Technical Report, 2076, U. S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey, 1959.

Reports results of ten successful Aerobee firings at Fort Churchill.

Boggess 59

Boggess, R.L., Brace, L.H., Spencer, N.W., "Langmuir Probe Measurements in the Ionosphere, " J. Geophys. Res., 64, 1627 (1959).

Letter report of design of a Langmuir probe which is ejected from rocket at peak altitude. Preliminary electron temperature from 1 rocket flight are presented

Havens 52

Havens, R.R., Koll, R., LaGow, H.E., "Pressure, Density, and Temperature of the Earth's Atmosphere," J. Geophys. Res., 57, 59-72 (1952).

Describes instrumentation for density measurements and presents data from 3 V-2, Viking flights.

Horowitz 57

Horowitz, R., LaGow, H.E., "Upper Air Pressure and Density Measurements from 90-220 Kilometers with Viking 7 Rocket," J. Geophys. Res., 62, 57-77 (1957)

Presents pressure and density data from a 1951 Viking flight, the highest altitude from which structure data have been obtained by rockets.

Horowitz 58

Horowitz, R., LaGow, H.E., "Upper Air Pressure and Density Measurements from 90-220 Kilometers with Viking 7 Rocket," J. Geophys. Res., 62, 57-77 (1957).

Pressure, temperature, and density data from an Aerobee flight at Ft. Churchill are compared with that obtained by the Viking 7 at White Sands.

Jones 58

Jones, L.M., Fischbach, F.F., Peterson, J.W., "Seasonal and Latitude Variations in Upper Air Density," IGY Rocket Report Series, 1, pp. 47-58, 1958.

Presents results of air density and temperature determination by falling sphere technique for 6 Nike-Cajun, 1 DAN, and 6 Aerobee rocket flights to July 1958.

Jones 59

Jones, L.M., Peterson, J.W., Schaeffer, E.J., Schulte, H.F., "Upper Air Densities and Temperature: Some Variations and an Abrupt Warming in the Mesosphere," J. Geophys. Res., 64, 2331-40 (1959).

Presents temperature and density data obtained in 8 Nike-Cajun rocket flights.

Upper Atmosphere Structure Data (cont.)

REFERENCES

LaGow 54

LaGow, H.E., "Physical Properties of the Atmosphere into the F_1-Layer," Rocket Explorations of the Upper Atmosphere, R.L.F. Boyd and M. Seaton, editors, pp. 73-81, Pergamon Press, Ltd., London, 1954.

Review of results from early NRL V-2, Viking Program at White Sands. Presents pressure, temperature, and density data obtained from 13 rocket flights.

Meadows 60

Meadows, E.B., Townsend, J.W., "IGY Rocket Measurements of Arctic Atmospheric Composition Above 100 Km.," Paper presented at COSPAR meeting in Nice, France, to be published in: Proceedings of the Symposium of the Committee of Space Science (COSPAR), North-Holland Publishing Co., Amsterdam, Late Summer, 1960 (Western Representative Interscience Publishers, New York).

Presents density data from 3 Aerobee-Hi flights based on mass spectrometer determinations.

Mikhnevich 60

Mikhnevich, V.V., Denilin, B.S., Repnev, A.I., Sokolov, V.A., "Some Results of the Determination of the Structural Parameters of the Atmosphere Using the Third Soviet Artificial Earth Satellite," J. Am. Rock. Soc., Russian Supplement, 30. 407-416 (1960).

Presents density, pressure, and temperature data to 500 kilometers obtained by instrumentation in the Soviet satellite launched 15 May 1958, 1958 δ. Also presents density data to 720 kilometers based on analysis of drag from orbits of Soviet satellites and carrier rockets launched 4 Oct. 1957 and 3 Nov. 1957.

Schilling 59

Schilling, G.F., Sterne, T.E., "Densities of the Upper Atmosphere Derived from Satellite Observations," Special Report No. 12, pp. 37-43, Smithsonian Astrophysical Observatory, Cambridge, 1958.

Summary of density values to 400 Kilometers inferred from satellite observations and drag calculations.

Sicinski 54

Sicinski, H.S., Spencer, N.W., Dow, W.G., "Rocket Measurements of the Upper Atmosphere. Ambient Temperature and Pressure in the 30-75 Km. Region," J. Appl. Phys., 25, 161-163 (1954).

Describes method for determination of ambient pressures and temperature based on ratio of pressure at nose cone tip to nose cone wall. Pressure and temperature data from 2 flights are presented.

Upper Atmosphere Structure Data (cont.)

REFERENCES

Spencer 54

Spencer, N.W., Dow, W.G., "Density-Gauge Methods for Measuring Upper-Air Temperature, Pressure, and Winds," Rocket Exploration of the Upper Atmosphere, R.L.F. Boyd and M. Seaton, editors, pp. 82, Pergamon Press, Ltd., London, 1954.

Describes ionization gage instrumentation for determination of temperature, pressure, and density. Data from 3 V-2 and 1 Aerobee rocket flights are presented.

Spencer 58-1

Spencer, N.W., Boggess, R.L., Taeusch, D., "Pressure, Temperature and Density at 90 Km. over Ft. Churchill," IGY Rocket Report Series, 1, pp. 80-91, 1958.

Review of experiments conducted by Dept. Electrical Engineering at University of Michigan in development of pressure sensing instrumentation. Presents results from preliminary data reduction from 2 Aerobee and 2 Nike-Cajun rocket flights.

Spencer 58-2

Spencer, N.W., Research in the Measurement of Ambient Pressure, Temperature, and Density of the Upper Atmosphere by means of Rockets, Final Report, Engineering Research Institute Project 2096, University of Michigan, June 1958.

Summary of research activities on radioactive ionization gage pressure measurement systems containing final report of "Air Force T-Day" experiment, and revised temperature data for Aerobee rocket flight.

Sterne 58

Sterne, T.E., Schilling, G.F., "Some Preliminary Values of Upper Atmosphere Density from Observations of USSR Satellites," Smithsonian Contrib. Astrophys., 2, 207-211 (1958).

Density values at altitude of 220-233 kilometers based on orbital data of 1957 α 1, α 2, and β 1.

Stroud 56

Stroud, W.G., Nordberg, W., Walsh, J.R., "Atmosphere Temperatures and Winds between 30 and 80 Km.," J. Geophys. Res., 61, 45 (1956).

Reviews results obtained with 12 Aerobee flights at White Sands.

Upper Atmosphere Structure Data (cont.)

REFERENCES

Stroud 60

Stroud, W.G., Nordberg, W., "Rocket Grenade Measurements of Temperature and Winds Over Churchill, Canada," Paper presented at COSPAR meeting in Nice, France, to be published in: Proceedings of the Symposium of the Committee of Space Science (COSPAR), North-Holland Publishing Co., Amsterdam, Late Summer, 1960 (Western Representative Interscience Publishers, New York).

Presents results of grenade experiments in 10 Aarobee rocket flights at Ft. Churchill between 1956 and 1958.

Weisner 54

Weisner, A.G., "The Determination of Temperatures and Winds Above 30 Km.," Rocket Exploration of the Upper Atmosphere, R.L.F. Boyd and M. Seaton, editors, pp. 133-142, Pergamon Press, Ltd., London, 1954.

Describes the instrumentation for grenade experiment and presents some data obtained from 6 Aerobee flights at White Sands.

Upper Atmosphere Composition Data Bibliography

Byram

Byram, E.T., Chubb, T.A., Friedman, H., "The Dissociation of Oxygen at High Altitudes," The Threshold of Space, M. Zelikoff, editor, pp. 211-216, Pergamon Press, Ltd., New York, 1957.

Presents composition data on molecular oxygen concentration for 3 Aerobee flights to an altitude of 180 kilometers.

Havens 52

Havens, R.R., Koll, R., LaGow, H.E., "Pressure, Density, and Temperature of the Earth's Atmosphere," J. Geophys. Res., 57, 59-72 (1952).

Describes instrumentation for density measurements and presents data from 3 V-2, Viking flights.

Horowitz 57

Horowitz, R., LaGow, H.E., "Upper Air Pressure and Density Measurements from 90-220 Km. with Viking 7 Rocket," J. Geophys. Res., 62, 57-77 (1957).

Presents pressure and density data from 2 1951 Viking flights. The highest altitude from which structure data have been obtained by rockets.

Horowitz 58

Horowitz, R., LaGow, H.E., "Summer Day Auroral-Zone Atmospheric Structure Measurements from 100-210 Km.," J. Geophys. Res., 63, 757-773 (1958).

Pressure, temperature and density data from an Aerobee flight at Ft. Churchill are compared with that obtained by the Viking 7 at White Sands.

Istomin

Istomin, V.G., "Some Results of the Measurements of the Spectrum Mass of Positive Ions by the 3rd Artificial Satellite," (Translated from Russian) NASA TECHNICAL TRANSLATION F-7, April 1960.

Presents radio frequency mass spectrometer data obtained from 225-980 kilometers. The composition data are strongly influenced by latitude of the orbiting satellite.

Johnson 54

Johnson, F.S., Purcell, J.D., Touey, R., "Studies of the Ozone Layer Above New Mexico," Rocket Exploration of the Upper Atmosphere, R.L.F. Boyd and M. Seaton, editors, pp. 189-201, Pergamon Press, Ltd., New York, 1954.

Paper summarizes and discusses data obtained by solar spectroscopy on vertical distribution of Ozone. Presents Ozone composition data to an altitude of 70 kilometers obtained by a NRL rocket.

Upper Atmosphere Composition Data Bibliography (cont.)

Jones 54

Jones, L.M., "The Measurement of Diffuse Separation in the Upper Atmosphere," Rocket Exploration of the Upper Atmosphere, R.L.F. Boyd and M. Seaton, editors, pp. 143-157, Pergamon Press, Ltd., London, 1954.

Describes devices for collecting samples from upper atmosphere. Samples, returned in steel bottles, were analyzed in laboratories for Helium, Neon, Argon, and Nitrogen. Data from 7 Aerobee and 5 V-2 flights are presented.

Meadows 60

Meadows, E.B., Townsend, J.W., "IGY Rocket Measurements of Arctic Atmospheric Composition Above 100 Km.," Paper presented at COSPAR meeting in Nice, France, to be published in: Proceedings of the Symposium of the Committee of Space Science (COSPAR), North-Holland Publishing Co., Amsterdam, Late Summer, 1960 (Western Representative Interscience Publishers, New York).

Presents composition data obtained on 4 Aerobee-Hi rocket flights instrumented with radio-frequency mass spectrometers. Instrumentation techniques and possible errors are discussed.

Wenzel 58

Wenzel, E.A., Loh, L.T., Nichols, M.H., Jones, L.M., "Diffusive Separation in the Upper Atmosphere," IGY Rocket Report Series, 1, pp. 91-107, 1958.

Reviews results of upper atmosphere sampling program. Composition data from 2 Aerobee flights are presented.

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APPENDIX C

Abstract Bibliography of Books, Review Articles, and Bibliographies on the Upper Atmosphere

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Abstract Bibliography of Books, Review Articles, and Bibliographies on the Upper Atmosphere

The publications listed below are recommended as background references in the field of upper atmosphere research.

Benson, O.O., Strughold, H., editors, Physics and Medicine of the Atmosphere and Space, John Wiley & Sons, Inc., New York, 1960.

Papers presented at 2nd International Symposium on Physics and Medicine of the Atmosphere and Space. Several review articles on upper atmosphere, but most of the papers are directed to problems of space flight.

Benton, M., editor, The Use of High-Altitude Rockets for Scientific Investigations, An Annotated Bibliography, U. S. Naval Research Laboratory, Washington, D. C., Bibliography No, 16, Oct. 1959.

This is an extensive bibliography of publications in the field of upper atmosphere research. Foreign as well as U. S. publications are included from 1946 to June 1959.

Boyd, R.L.F., Seaton, M.J., editors, Rocket Exploration of the Upper Atmosphere, Pergamon Press, Ltd., London, 1954.

Report of 1st major international conference concerned with rocket exploration of the upper atmosphere. The papers present a summary of experimental data to 1954.

Hanessian, J., Guttmacher, I., editors, IGY Rocket Report Series, 1, Experimental Results of the U. S. Rocket Program for the International Geophysical Year to 1 July 1958, National Academy of Sciences, Washington, D. C., July 1958.

This compilation of research papers presents the results obtained during the first 12 months of the U. S. IGY program. The bulk of these papers were presented at the CSAGI Assembly held in Moscow in the summer of 1958.

Kuiper, G.P., editor, The Earth as a Planet, University of Chicago Press, Chicago, 1954.

This book contains several lengthly review articles on the structure and composition of the atmosphere.

Massey, H.S.W., Boyd, R.L.F., editors, The Upper Atmosphere, Philosophical Library, New York, 1959.

A general discussion of upper atmosphere phenomena studied during IGY; few experimental data, but good generalized summaries.

Abstract Bibliography of Books, Review Article, (cont.)

Newell, H.E., editor, <u>Sounding Rockets</u>, McGraw-Hill, New York, 1959.

This book presents performance characteristics of the principal atmospheric research rockets developed since the end of World War II.

<u>Proceedings of the Symposium of the Committee of Space Sciences (COSPAR)</u>, to be published by North-Holland Publishing Co., Amsterdam, Late Summer 1960 (Western Representative Interscience Publishers, New York).

This book, to be published in the late summer of 1960, contains the paper presented at the First International Space Science Symposium held in Nice, France, Jan. 1960. The papers include the results obtained by the upper atmosphere research programs of most of the countries participating in the IGY program.

Wright Instruments, Inc., Vestal, New York, <u>A Survey of Pressure & Density Sensors & Associated Problems for The NOL Hasp Program</u>, Final Report, April 1959.

A survey of "state of the art" in development of miniature pressure and density sensors.

Zelikoff, M., editor, <u>The Threshold of Space</u>, Pergamon Press, Ltd., New York, 1957.

Proceedings of Conference on Chemical Aeronomy at Cambridge, Mass. in June 1956, sponsored by the Geophysics Research Directorate of the Air Force, Cambridge Research Center. This book contains papers by most of the active research workers in the fields of atmospheric composition and photochemistry.

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CPWC/TRC May 6, 1999

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- DASA-2214, AD-854912, STATEMENT A
- DASA-2627, AD-514934, STATEMENT A
- DASA-2651, AD-514615, STATEMENT A
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Ardith Jarrett

ARDITH JARRETT
Chief, Technical Resource Center